A STATISTICAL ANALYSIS OF THE DEATH CAUSES OF THE PRIMATES OF BUDAPEST ZOO IN A PERIOD OF 10 YEARS

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Chapter One

1. Introduction

1.1 Background of the Study

The word Zoo is utilized generally to refer to any public or private institutions that room live animals, mainly with the aim of show to the people. Zoos are constant places that are open to the people to present education, recreation, and cultural pleasure. Zoos, for the aim of this point, are not temporary exhibition like circuses or petting zoos. Nor are zoos private sets of peculiar animals. Therefore, ‘‘Zoos,’’ contain the equipment that is conventionally regarded zoos, like zoological parks and aquariums, along with lots of wildlife places and ‘‘bio parks,’’ beside several insect houses and the former site breeding places. At the present time, there are more than 1200 well established zoos in all over the world (Marie, Wharton, 2013).

Non-human primates can transfer different types of zoonotic diseases. Thus, appropriate protection need to be taken by people who is encountering these animals to inhibit probable exposure to zoonotic pathogen. To make the recognition and control of probable pathogens easy, all equipment that house non-human primates have to apply comprehensive microbial quality plans. This will assist to decrease the morbidity and mortality of such kinds of wild animals.

1.2 Statement of the Problem

Zoos present a special and great resource for primate studies. Primate species that would mostly be hard to put in situ or would cause major field study expenses can be researched in zoos (Hosey, 1997). Different kinds of pure and applied subjects that might be researched in zoos are diverse and simplify intra- and inter specific comparative researches (Kleiman, 1985; Hosey and Druck, 1987; Melfi, 2001).Most of primates live in zoos are handled in more ‘naturalistic’ environment these days, which can present a better life condition for them.

Studies in zoos have been increasing continuously within the past 40 years (Morris, 1966; Kleiman, 1985; overview Hardy, 1992). As the World Zoo Conservation Strategy (1993) puts

it, most of the zoos confirmed the essential of study by involving it in their mission statement and objectives. Sporadically, studies have been conducted to examine zoo research, either by research institutions (Finlay and Maple, 1986; Hardy, 1992; Nogge, 1997; Stoinski et al., 1998) or publications made in related journals (Hardy, 1992; Hosey, 1997).The results show that zoo-housed primates are the common subjects of many studies. Finlay and Maple (1986) discovered that 82% of zoos in America that replied to their survey were doing researches of their primates. Another study, utilizing the Consortium of Aquariums, Universities and Zoos (C.A.U.Z.) database for information collected in spring 1993, mentioned that 43.7% of projects (total N = 370) were carried out on primates (Hardy, 1992). Great apes were the common primate family researched (38% of120 studies, Finlay and Maple, 1986; 15% of 370 studies, Hardy, 1992).

In spite of the fact that there are 200–300 species in the order Primates related to the reference source and taxonomic scheme cited, this study emphasizes species within the eleven genera most commonly showed in zoos. Among them are rhesus monkeys, Gibbon, Chimpanzee, white-headed capuchin, Macaque, Squirrel monkey, Pygmy marmoset, Ring-tailed lemur, Cotton-top tamarin, Orangutan, Guereza.

This study is aimed to provide an overview of the death causes of primates in Budapest Zoo during a ten years long period of the eleven most commonly used primate genera.

1.3 Significance of the Study

Recently, primate populations have impacted by a large demographic decrease (Walsh, Abernethy, Bermejo, Beyers, De Wachter, et al, 2003 and Campbell, Kuehl, N'Goran Kouamé, Boesch, 2008). These decreases are because of some reasons; mostly the causes were human practices such as hunting or destruction of their habitat and/or infectious disease epidemics as their key fundamental.

1.4 Key Terms of the Study

1.4.1 Primates:

Mivart (1873) defined primates as "an unguiculate, claviculate, placental mammal with orbits encircled by bone; three kinds of teeth at least at one time of life; brain always with a posterior lobe and a calcarine fissure; the innermost digits of at least one pair of extremities opposable; hallux with a flat nail or none; a well-marked caecum; penis pendulous; testes scrotal; always two pectoral mammae."

1.4.2 Budapest Zoo:

Budapest Zoo is the oldest zoo park in Hungary and one of the oldest in the world. It has 1,072 animal species and is located within Városliget Park. The area is a nature reserve, and has some valuable art nouveau buildings. More than 1,000 species are living there. Before, the zoo displayed mainly Hungarian species and some rare species of monkeys, parrots, camels, and kangaroos, among others. Franz Joseph and Queen Elizabeth donated a giraffe and other animals to the zoo. The first lion house opened in 1876 with lions and tigers. An elephant, a hippopotamus, and a rhinoceros joined later on.
(https://en.wikipedia.org/wiki/Budapest_Zoo_and_Botanical_Garden).

Primates as explained before are the group of mammals where various monkeys and their closest relatives the prosimians, lemurs belong. The zoo shows especially many species of this group though not definitely in the neighborhood of each other. In the South-America House for example the squirrel monkeys live, in the house named after János Xántus visitors can see the Javan surilis and visitors can see primates in the Madagascar House as well. They have developed a completely separate place for the apes. The animal house itself was built in 1997, but they have redecorated both the internal and outer spaces since then. The residence of the apes stands in its present shape since 2008 apart from connecting the building with the internal spaces of the Magical Hill in 2012. The building is the home of gorillas and orangutans. There is a spacious, separated with glass walls from visitors, variable inner space and also an enormously enhanced grassy yard available for both species. The gorillas' yard in itself is more than 1,000 square meters, for which the old lion yards and the walking path in front of that was used (http://www.zoobudapest.com).

1.4.3 Captive Ring-tailed lemur (*Lemur catta*)

The Captive Ring-tailed lemur (*Lemur catta*) is a non-human, arboreal primate which is native of islands of Madagascar. It is able to eat anything and is a terrestrial and diurnal animal. The Ring-tailed lemur is very social, can be in a group of 30 individuals and it is an endangered species as the IUCN Red List of Threatened Species puts it (Andriaholinirina *et al*., 2014).

1.4.4 Chimpanzee (*Pan troglodytes*)

The Chimpanzees (Pan troglodytes) are categorized as an extremely endangered species (http://www.iucnredlist.org/details/15936/0) because of developing human practices that have direct (by poaching and bush meat hunting) or indirect (by logging, mining and human-

induced habitat fragmentation) harmful impacts on their life. Furthermore, infectious diseases, like Ebola haemorrhagic fever, paramyxovirosis, anthrax and pneumonic streptococcosis, have extra effects on the vulnerable inhabitants (Formenty et al. 1999; Leendertz et al. 2006; Chi et al. 2007; Kaur et al. 2008).

1.4.5 Macaque (Macaca)

There are two mainly macaque species that are popularly utilized in studies: rhesus macaques (Macaca mulatta) and cynomolgus macaques (Macaca fascicularis). Beside to immunologic resemblance, the extent of infection results, clinical existence, and pathology in these macaques can be significantly the same as human especially in TB (Via et al 2008; Barry et al, 2009; Lin et al, 2006; Lin et al, 2009; Mattila, et al 2013; Phuah, et all 2012). Although these two macaque species are genetically similar, there are differences in their resistance to some infection, with rhesus macaques (Macaca mulatta) being more susceptible to developing active disease than similarly infected cynomolgus macaques (Macaca fascicularis) (Sharpe, et al, 2009; Langermans et al, 2001, authors' unpublished data).

Rhesus macaque (Macaca mulatta) is basically discovered in southern Asia crossing eastern Afghanistan, Bangladesh, Bhutan, northern and central India, central and southern China, Lao PDR, Myanmar, Nepal, northern Pakistan, northern Thailand, and Vietnam, and is an endangered species because of the decrease in the amount entirely its broad extension lately. This species is mentioned in CITES Appendix II, Schedule III of the Bangladesh Wildlife (Preservation) Act (1974), Schedule I of Part I of the Indian Wildlife (Protection) Act (amended up to 2002), and Category II of the Chinese Wildlife Protection Act (1989).

1.4.6 Gibbon (Hylobatidae)

The Gibbons (Hylobatidae) can be defined as small apes living in the forests of Southeast, South, and East Asia. They are from the similar super family as humans and the rest of great apes (Hominoidea), and their same ancestor was the first to come from the other hominoids (e.g., Matsudaira and Ishida 2010; Van Ngoc, Mootnick, Li et al. 2010). Many of gibbon species are regarded "endangered" or "critically endangered" (IUCN 2009), and the Hainan gibbon (*Nomascus hainanus*), with about 20 existing ones, is the scare primate in the world (Mootnick et al. 2007).

1.4.7 Squirrel monkey (Saimiri)

The Squirrel monkey (Saimiri) can be considered as one of the most platyrrhine taxa in respect to its species variety (Alfaro et al., 2015). This animal can be found basically in the Amazon basin and the Guianas, in Central America, Costa Rica and Panama (Chiou et al., 2011).

1.4.8 Pygmy marmoset (Callithrix [Cebuella] pygmaea)

The Pygmy marmoset (Callithrix [Cebuella] pygmaea) is one of the Callitrichidae animals in the order Primates, it can be considered as the smallest New World monkey. This animal belongs to the forests of South America (Rylands and Mittermeier, 2009). As previous researches showed, pygmy marmosets (Callithrix [Cebuella] pygmaea) look to be permeable to viral and bacterial pneumonias, e.g. infections resulted through paramyxoviruses, adenoviruses (AdVs), Klebsiella sp., Bordetella sp., and Streptococcus sp. (Joslin, 2003). Rhinitis, conjunctivitis beside to systemic symptom which has been mentioned following an influenza virus infection (Joslin, 1986).

1.4.10 Cotton-top Tamarin (Saguinus oedipus)

The Cotton-top tamarin (Saguinus oedipus) is one of the small New World monkeys. The diet of this animal basically includes insects, ripe fruits, plant exudates, floral nectar, reptiles and amphibians (Watkins, Letvin, 1993; Taylor, Vinyard, 2004). It is a pint-sized lower order, New World primate of the order Callitrichidae (Clapp, Nardi, Tobi, 1993). This amazing monkey presents a pattern for human disease in Enteritis [Wood, Peck, Tefend, Stonerook, Caniano, Mutabagani, Lhoták, Sharma, 2000, Mansfield, Lin, Xia, Newman, Schauer, MacKey, Lackner, Carville, 2001), Lymphoma (Hofmann, Kahnt, Mätz-Rensing, Brack, Kaup, 2001), large intestine cancer (Lushbaugh, Humason, Swartzendruber, Richter, Gengozian, 1978), immune-altered states (Watkins, Letvin, 1993) and recently liver metastases (Tobi, Kim, Zimmer, Hatfield, Kam, Khoury, Carville, Lawson, Schiemann, Thomas, 2011).

Chapter Two

Review of the Literature

2.1 Overview

In this chapter the discussion of some causes of death are presented.

2.2 Myocarditis

Fiedler, (1900) defined isolated myocarditis in man and a review of the literature from that time reveals lots of publications of this situation in both man and animals. Furthermore, a long list of bacterial and other agents have been proposed as etiologic elements in most of these publications. The lesion has been mentioned as different kinds of names; for instance, Fiedler's myocarditis, myocarditis of unknown etiology, allergic, isolated, primary, interstitial, circumscribed, diffuse, and idiopathic myocarditis. The microscopic outcomes in these mentioned cases have confirmed polymorphonuclear and mononuclear interstitial infiltration, frequently with necrosis of myocardial fibers.

From Fiedler's first report, (Fiedler, 1900) myocarditis evidently has been made under variable situations in some various laboratory animals but without enough changes for major recognition. Miller (1924) reported a myocardial lesion happening in rabbits which had been identified to be otherwise in good health. Microscopically, such lesions contained lymphocytes and endotheial leukocytes, and only sometimes were granulocytes, plasma cells, and fibroblasts seen (Schmidt, 1948).

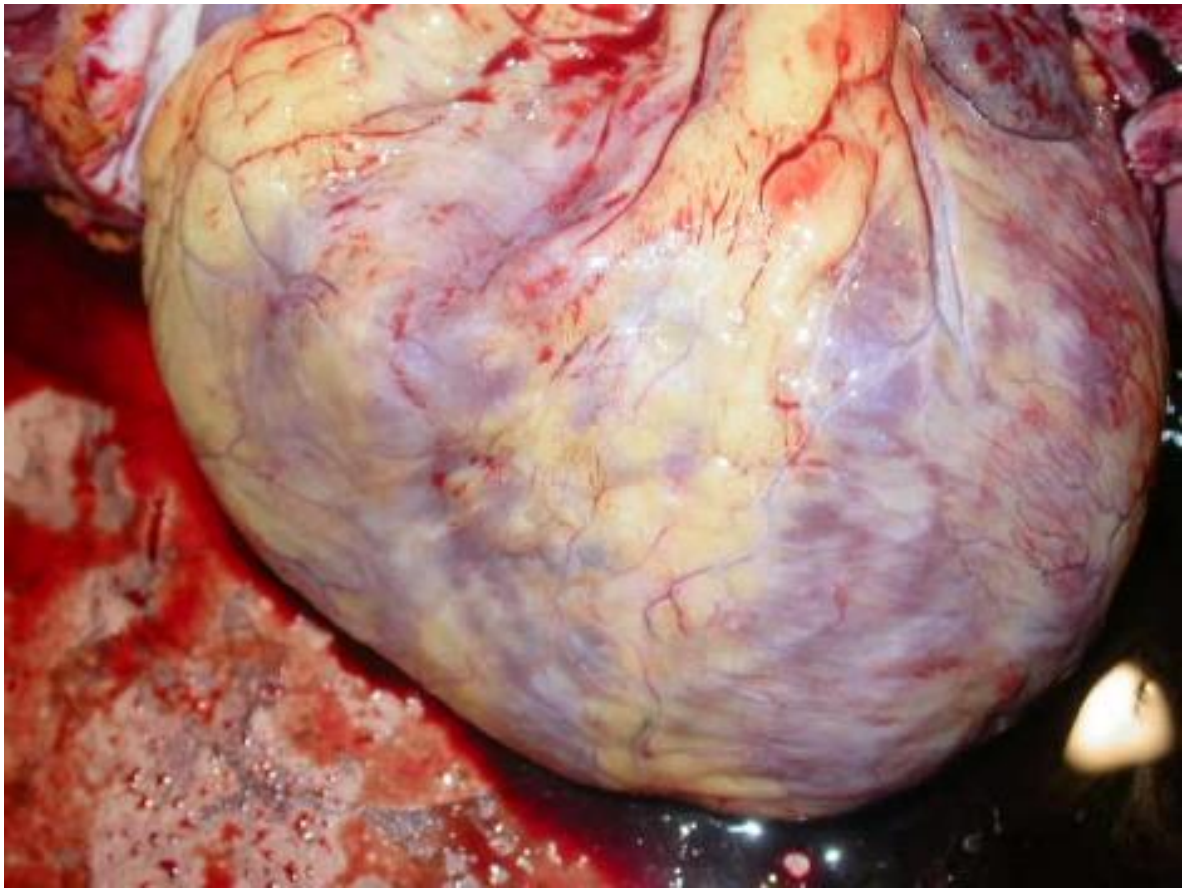


Figure 1: Diffuse Mycarditis in a 20 years old male chimpanzee

Schmidt (1948) worked on virus myocarditis, pathologic and experimental studies, and made a summary of his work as follow:

- An agent was isolated from a chimpanzee dying of interstitial myocarditis which produced myocarditis and encephalitis in mice and hamsters and myocarditis in guinea-pigs.
- This virus produced a range of cardiac lesions from sight perivascular lymphocytic infiltration to advanced myocardial necrosis and granulocytes infiltration.
- The agent was found to be potent and specific when introduced intravenously, intraperitoneally, subcutaneously, intracranially, and by intranal instillation. It seemed to be widespread in various organs since it could be transmitted by suspensions of a variety of viscera.
- This virus has not been identified with any of a variety of known viruses by various biologic tests
- The morphologic findings in the heart in this disease duplicate to a remarkable degree myocardial lesions found in human heart muscle in several virus disease in patients in whom clinical manifestations were observed prior to death (p.106).

Figure 2: Necropsy of a 20 years old male chimpanzee

2.3 Cardiomyopathy

Cardiovascular diseases, like idiopathic cardiomyopathy (IC), congestive heart failure, arteriosclerosis and atherosclerosis have been recorded in chimpanzees (Pan Troglodytes) (Hansen et al, 1984; Hubbard et all, 1991; McNamara et all, 1987; Schmidt, 1978), and gorillas (McNamara et all, 1987; Schulman et all, 1995). Idiopathic cardiomyopathy has been given special attention because of the high spread in chimpanzees (Hubbard et all, 1991). Idiopathic dilated cardiomyopathy is the great popular kind of IC in humans. It makes reduced ejection fraction, dilated chambers, cardiomegaly and also fibrosis and hypertrophy of cardiac cells (Schoen, 2005). The first publication of IC in a captive chimpanzee was reported in 1984 (Hansen et all, 1984), and IC has been recognized with progressing repetition in our colony. Heart disease, with a high percentage of IC, was the major reason of death in chimpanzees at

the Southwest National Primate Research Center (SNPRC) at the South west Foundation for Biomedical Research in San Antonio, Texas between 1982 and 1989 (Hubbard et all, 1991).

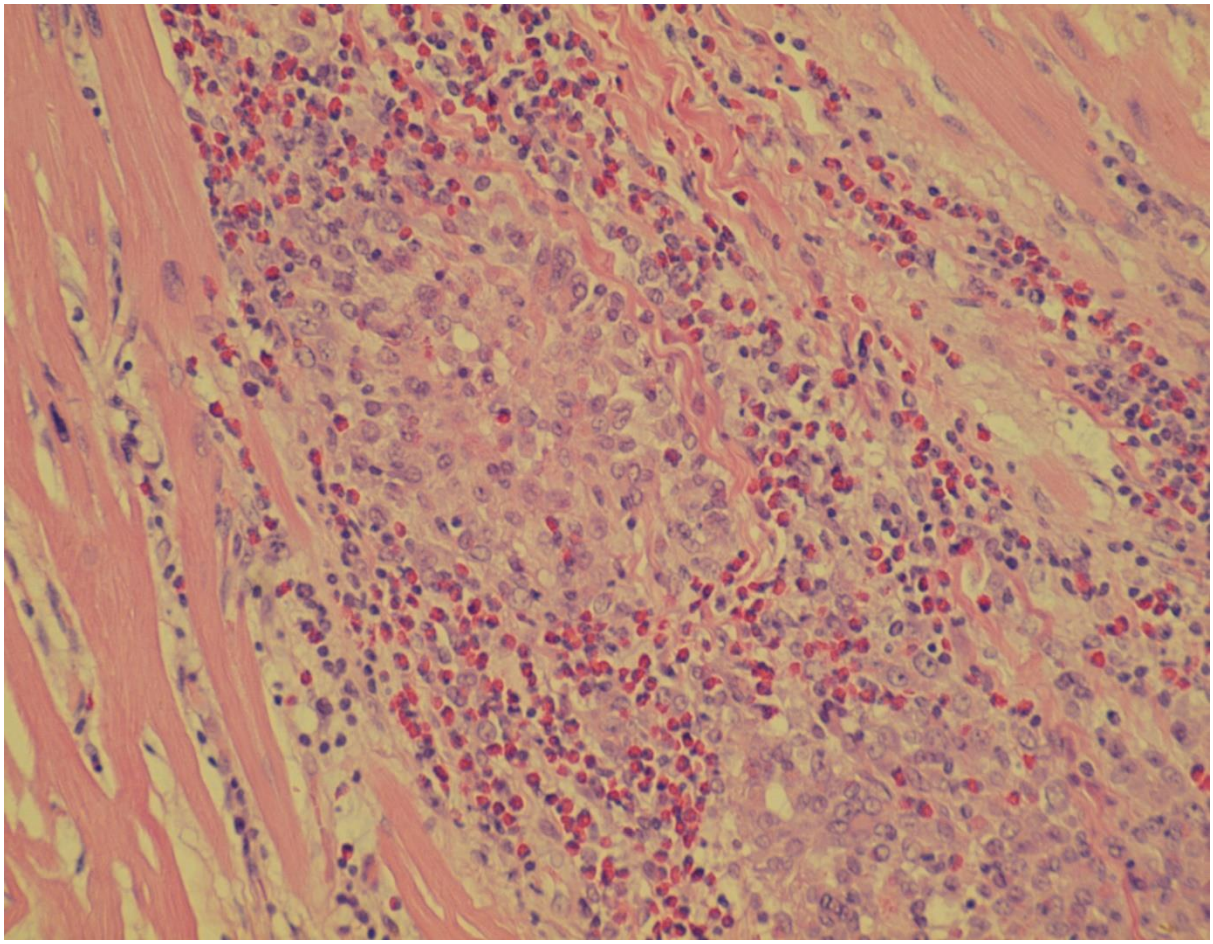


Figure 3: Diffuse Myocarditis

2.4 Tuberculosis

Tuberculosis (TB) can be created by very closely associated acid fast bacteria name as the *Mycobacterium tuberculosis* complex (MTBC) (Cole et all, 1998). MTBC contains the usual human-related pathogens *M. tuberculosis* and *M.africanum* (de Jong et all, 2010); *M. canettii* and other called "smooth TB bacilli" (Gutierrez et all, 2005).), the real host extent of which rest unknown; and some lineages suit to various mammal species that contain *M. bovis*, *M. microti*, *M. caprae*, *M. orygis*, and *M. pinnipedii* (Brosch et all, 2002; Huard et all, 2006; van Ingen et all, 2012). Due to the broad host extent of animal-related MTBC, the popular approach till a decade ago was that human TB strains had created from *M. bovis*, the typical agent of bovine TB.

Lately comparative genomic analyses have questioned this approach by revealing that animal MTBC strains rest within the genetically more different human MTBC strains (Brosch et all, 2002 Gagneux et all, 2006 Garnier et all, 2003). These outcomes not only rejected the theory of an animal origination for human MTBC but also improve another hypothesis for a human origin of animal MTBC (Smith et all, 2006).). However, not so much is clear about MTBC variety in household animals, and even less is clear about MTBC variety in wildlife, containing our phylogenetically closest family, the great apes. It is worth to note that, modern members of MTBC impacting wild mammals in Africa have lately been found (Cousins et all, 1994; Alexander et all, 2010). A study that proposes animal MTBC is more various than what before thought.

The non-human primate (NHP) pattern of tuberculosis (TB) is a significant translational pattern of human disease that connects the gap between other animal patterns and humans. NHPs are genetically very close to humans of any of the experimental animals utilized in biological study, with correlated significant immunologic resemblance to humans. Whereas there are lots of difficulties to utilize NHPs in study, containing TB study, there are also lots of profits. Practically approach, lots of human reagents cross-react with NHPs and can be utilized easily, particularly in macaques. The immunologic resemblance makes one to perceive that vaccines and adjuvants will have similar impacts in NHPs as in humans, and this has been discovered in some researches Flynn et all, 2015).

2.5 Pseudotuberculosis

Pseudotuberculosis is made either by Yersinia (previously Pasteurella) pseudotuberculosis or by Y. enterocolitica (Wetzler, 1970). It can impact a broad extent of avian and mammalian species, containing man, in whom it makes mesenteric lymphadenitis (Knapp, Massboff, 1954) and scarcely a deadly septicemia. An international symposium which was in 1967 regarded the microbiology and epidemiology of the disease more specifically (International Symposium on Pseudo tuberculosis, Paris, 1967). The people who were participated the meeting confirmed that the disease is probably to be more common in man and animals than currently discovered (Mlollaret, 1967), In spite of the fact that it can be regarded as a disease principally of rodents, it has frequently been documented in nonhuman primates, particularly in Europe.

However, it has to be accepted that, pseudotuberculosis frequently emerges without morphologic signs of intestinal participation. For instance, in mesenteric lymphadenitis in young individual (the popular type of human pseudotuberculosis), lesions created by either organism are mainly restricted to the mesenteric lymph nodes (Knapp, 1958). In baboons

(Papio papio), Y. pseudotuberculosis made mainly central necrosis in the mesenteric nodes. In other nonhuman primates, intestinal lesions were scare in the existence of necrotic foci in the spleen, liver and even the lungs and kidneys (Verge, Placidi, 1942; Urbain A 1942).

2.6 Heart hypertrophy

Hypertension as one of the main reasons of heart hypertrophy related to particular morphological shifts of the myocardium, like fibrosis, is too much connected to a complicated cascade of events resulting in atherogenesis (Ross, 1993). With each other, these structural shifts atrophy the functional status of the cardiovascular system.

2.7 Cirrhosis of the liver

Cirrhosis is a progressive injury of liver followed by fibrosis and alteration of the liver architecture into the abnormal nodules that lack normal lobular organization. The common causes of liver cirrhosis are hepatitis, hepatitis C, alcohol and hemochromatosis. The clinical manifestations include jaundice, portal hypertension and varices, ascites, hepatorenal syndrome, spontaneous bacterial peritonitis, hepatic encephalopathy and progressive hepatic failure (Pichakron *et al*, 2007)

2.8 Interstitial Pneumonia

Interstitial lung diseases (ILD) are among the diverse class of afflictions. Some of them which can be named as the clinical courses of idiopathic pulmonary fibrosis (IPF) and nonspecific interstitial pneumonia (NSIP) are diverse. These entities have a specific CT model that help to the primary diagnosis but is restricted in respect to the disease act and prognosis.

Nonspecific interstitial pneumonia (NSIP) is a different entity which can be diagnose by a multidisciplinary view (Travis et all, 2013; Travis et all, 2008). This entity is different from other ILD due to the fact that NSIP reveals a distinct clinical course (Travis et all, 2013). In spite of the point that it is frequently idiopathic, the histologic pattern of NSIP has been seen in different clinical situations, containing connective tissue diseases (CTD), chronic hypersensitivity pneumonitis, and drug toxicity and slowly resolving diffuse alveolar damage (Nunes et all, 2015). The high resolution CT scan (HRCT) results in NSIP are bilateral, symmetric ground glass opacities; mainly basal reticular opacities with traction bronchiectasis; and volume loss (Travis et all, 2013). Pathological examinations by a lung biopsy is suggested for idiopathic types of the disease (Travis et all, 2013). NSIP is described histologically through different extents of interstitial inflammation and fibrosis that are temporally and morphologically similar. The histological spectrum of NSIP spans from a mostly cellular

procedure (i.e., cellular NSIP) to paucicellular lung fibrosis (i.e., fibrotic NSIP). Cellular types show identical alveolar septal infiltrates of lymphocytes and plasma cells, while fibrotic types show a similar collagen accumulation leading to broadening of alveolar septa, peribronchiolar interstitium, interlobular septa, or visceral pleura (Travis et all, 2013).

2.9 Shock

Gram-negative sepsis and septic shock are complicated disease condition described by substantial hemodynamic, cardiovascular, and metabolic disturbances that might lead in multi-organ inability (Luce, 1987; Harris et all, 1987). Due to its high mortality amount (Young et all, 1977), this disease is a main health issue. Although lots of studies has been carried out to describe the gross pathophysiological shifts connected to these diseases, therapeutic interventions have been greatly in use. Effective inhibition and therapy have to be according to perceive of the mechanisms which sepsis and septic shock are based on.

2.10 Septicemia (Sepsis)

Sepsis as a clinical syndrome described by the existence of both infection and the systemic inflammatory response syndrome (SIRS). Nevertheless, because infection cannot be always microbiologically acknowledged, the diagnostic measurements are infection (suspected or confirmed) and the existence of few of the SIRS measurements.

Severe sepsis is the sepsis involved by organ dysfunction. In the 8th Edition of the ICD-10-AM/ACHI/ACS1 this is broadened to contain organ inability. This difference does not impact the guideline diagnostic measurements which recognize a minimum level of organ dysfunction beyond which severe sepsis is diagnosed.

Septic shock can be described as severe sepsis with circulatory shock with symptoms of organ dysfunction or hypo perfusion in the 8th Edition of the ICD-10-AM/ACHI/ACS. The diagnostic measurements in this guideline are used after 30mls/kg isotonic fluid has been performed to inverse any hypovolemia and constant systolic blood pressure <90 mmHg, Mean Arterial Pressure < 65 mmHg, reduced by 40mmHg from baseline and/or lactate >4 mmol/l. (National Clinical Guideline 2014).

2.11 Endometritis

Chronic endometritis (CE) a local inflammatory situation identified as superficial mucosal edematous shift, elevated stromal cell density, and dissociated maturation between epithelial

cells and stromal fibroblasts, and PC infiltration in the endometrial stromal areas (Michels ,1995).

Figure 4: Endometritis in a pygmy Marmoset

Whereas CE is the benign pathology with tender nondescript gynecologic symptoms, its suitable histopathologic diagnosis has been difficult and requires so much time. As a result, CE is subject to be disregarded in gynecologic experience. Nevertheless, the close connection of CE with infertility and perinatal and neonatal complications is manifesting (Kitaya, et all, 2016).

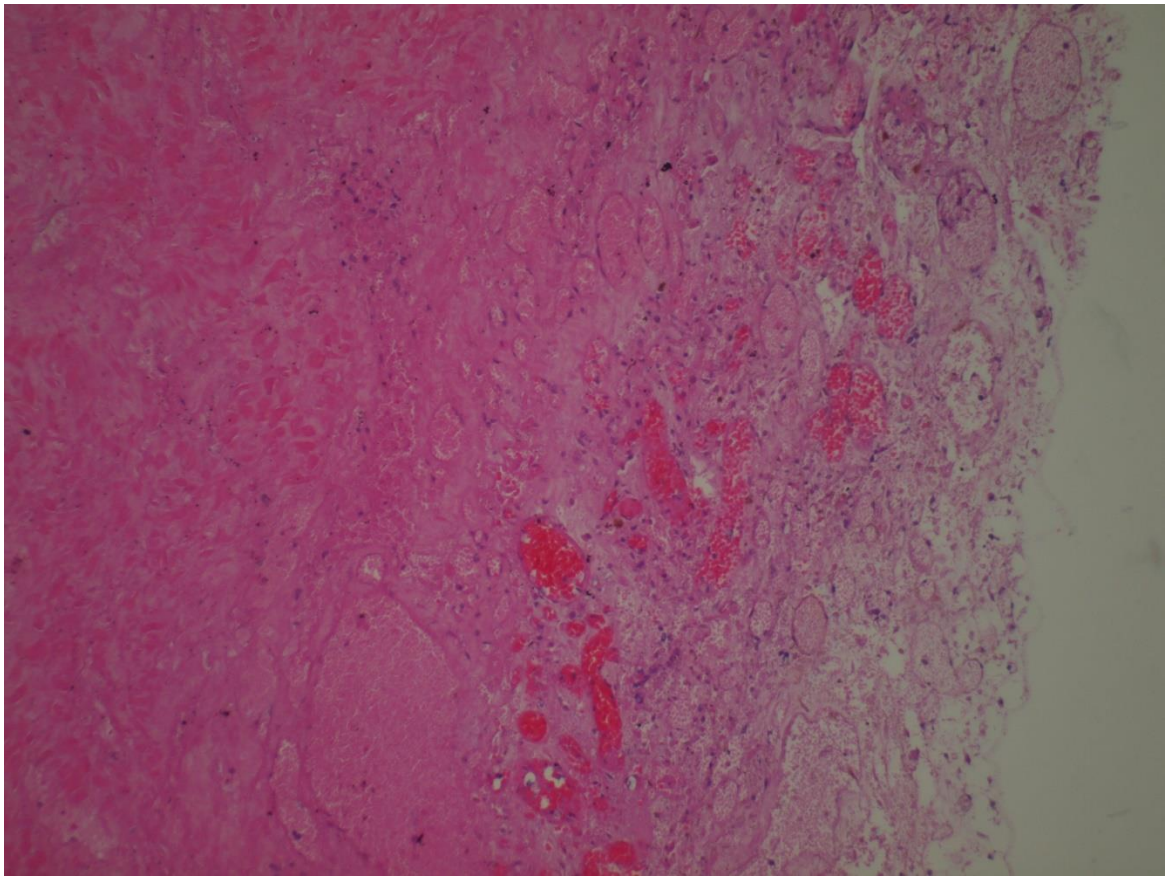


Figure 5: Endometritis in a pygmy Marmoset

CE is frequently asymptomatic or oligosymptomatic with mild indefinite development such as atypical uterine bleeding, pelvic pain, and leucorrhea. Moreover, the importance of the invasive endometrial biopsy and laborious histopathologic investigations makes investigating CE difficult.

2.12 Cryptogenic multifocal ulcerous stenosing enteritis

Cryptogenic multifocal ulcerous stenosing enteritis is an infrequent idiopathic disease of the small intestine. Its source and pathophysiology have not been determined. Clinicopathologic characteristics contain unknown small intestine strictures with superficial ulceration, chronic or relapsing occlusion episodes (Kwon et all 2012). It mainly reacts ideally to glucocorticosteroids (Debray et all, 1964; Perlemuter, et all, 2001).

2.13 Yersinia Pseudotuberculosis

Yersinia pseudotuberculosis is a Gram-negative coccobacillus which comes from the Enterobacteriaceae background, a rare involved pathogen in control of sporadic prevalence of disease in non-human primates and man (McClure and King, 1984). This disease contains different types. In non-human primates, man and captive exotic ungulates, it is a fulminating,

necrotizing, ulcerative enteritis, often with mesenteric lymphadenitis. Septicaemia can result in localization of the organism in visceral organs, often liver and spleen, with broad caseating abscesses (Brown and Davis (1989).

Chapter Three

Methodology

3.1 Introduction

The aim of the present study was to investigate the Statistical analysis of death causes of primates in Budapest Zoo during a ten years long period. Accordingly, this chapter provided information on the methodology of the study including population and data collection procedures and eventually data analysis that was done for answering the research question.

3.2 Population of the Study

A total of 27 primates which were from 11 species were investigated in this study. These species were included Rhesus monkey, Gibbon, Chimpanzee, white-headed capuchin, Macaque, Squirrel monkey, Pygmy marmoset, Ring-tailed lemur, Cotton-top Tamarin, Orangutan, and Guereza. Primates involved 8 males, 9 female, and we had no information about the gender of 10 primates. Animals were approximately adult and the middle value was equal to 3. The table 3.1 shows the ages of primates.

Table 3.1 Frequency of the age of Primates

Measures	F	Middle
< 5 years	1	3
5-10 years	3	
Adult	11	
No information	12	
Total	27	

3.3 Data Collection Process

Data collection process was done by taking necropsies of dead monkeys in Budapest Zoo, Checking database of results of former necropsies and literature review of the diseases found by the necropsies (see appendix for sample images).They were examined based on the causes of death which were as follow: Acute lymphadenitis (Lymphadenitis), Atrophy,

Tuberculosis (General), Cardiomyopathy(Hypertrophic), the prevalence of myocarditis, interstitial pneumonia, Shock, Diarrhea and hepatitis caused by Yersinia sud and tuberculosis, Septicemia caused by E. coli, Endometritis caused by the effect of general objects and consequential peritonitis, Itoh ulcer diarrhea caused by sp, Cirrhosis of the liver, Consequential poisoning Phlegmone caused by sp Staphylococcus, Heart muscle hypertrophy, Poisoning Patsy caused by Salmonella, Heart valve dysplasia in the hole of left atrium and consequential shock,Osteodystrophiafibrosa and consequential cachexia, Renal insufficiency, tubular nephritis, Kataral pneumonia (pneumonia Kataral), Lymphoma, Metritis, severe inflammation of the intestine, Toxoplasmosis, A type of liver cancer.

3.4 Data Analysis Process

To analyze data, SPSS software was used. Descriptive data included mean, and frequency tables for the overall characteristics of the population were obtained. Inferential analysis was composed of X2 test and Multi logistic Multivariate regression analysis. X2 test was run to investigate the significant relationship between the characteristics of the population two-dimensionally. Multi logistic Multivariate regression analysis was employed to investigate the effect of the variables of species, sex and age of the mammals on the cause of death in monkeys.

Chapter Four

Results

4.1 Introduction

In any Study, the researcher collects data to answer the questions and hypotheses. To convert data from an irregular set into a systematic and organized set, it is necessary to classify, summarize and adjusted data using common methods, and to show data in tables and statistical charts to be able to respond the considered questions. Data analysis, as a part of the process of scientific method, is one of the main bases of any research by which all research activities are guided and controlled to achieve a result. In other words, in this section, the researcher uses different methods of analysis to answer the developed questions or issues with two basic goals: 1. describing the empirical evidence which are collected through observation, experimentation, etc. on the research topic 2. Interpreting descriptive and inferential result to assess the questions and to test the research hypotheses (Hooman, 2000). So, in this chapter, SPSS was used to answer the questions and hypotheses. In this chapter, first, descriptive statistics and tables relating to the sample characteristics are discussed. Identifying the sample characteristics is useful because in this way, the overall characteristics of the population are investigated and the general characteristics are determined for other researchers. Then, in the following, using appropriate statistical tests, the hypotheses are tested and finally, the evaluation matrix of internal and external factors, and the related strategies are developed.

4.2 Descriptive statistics

Table 4.1. The frequency distribution based on each species of primates

Measures	F	F (%)	Mode
Rhesus monkey	2	7.4	6
Gibbon	1	3.7	
Chimpanzee	4	14.8	
white-headed capuchin	1	3.7	
Macaque	3	11.1	
Squirrel monkey	6	22.2	
Pygmy marmoset	4	14.8	
Ring-tailed lemur	1	3.7	
Cotton-top tamarin	3	11.1	
Orangutan	1	3.7	
Guereza	1	3.7	
Total	27	100.0	

The statistics and figures of table 4.1 show that 7.4% of the studied monkeys are Rhesus monkey, 3.7% Gibbon، 14.8% Chimpanzee, 3.7 % white-headed capuchin, 11.1% lemur, 3.7% Orangutan, 3.7% Guereza. The mode value is 6 which shows that the Squirrel monkey has the highest frequency.

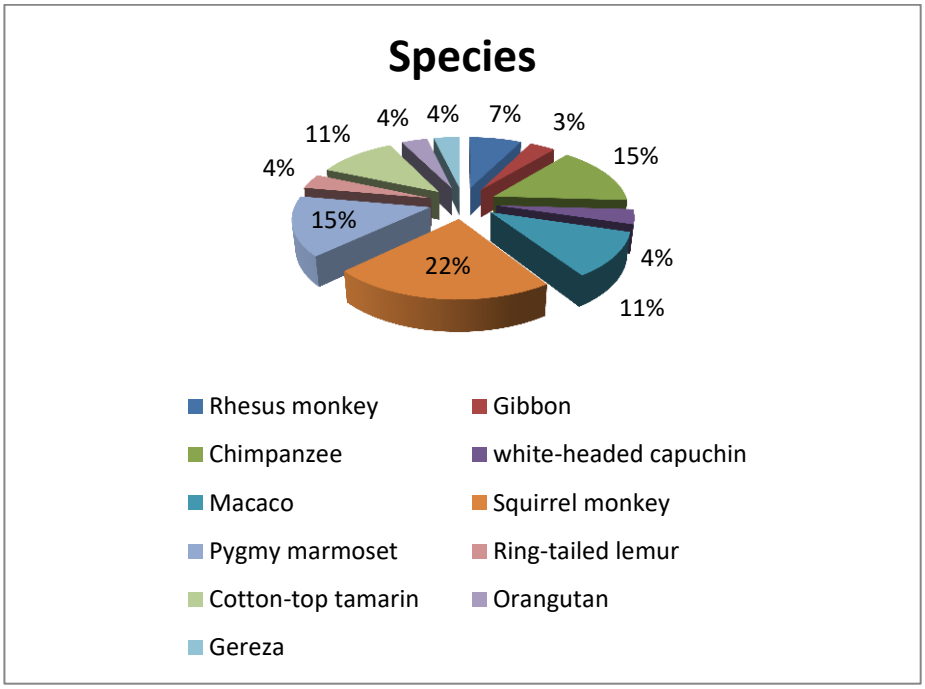


Table 4.2. Frequency Distribution based on the gender of primates

Measures	F	F (%)	Mode
Male	8	29.6	2
Female	9	33.3	
No information	10	37.0	
Total	27	100.0	

Statistics and figures, presented in table 4.2, indicate that 29.6 % of monkeys are male and 33.3% are female. Also, there is no information about the gender of 37% of monkeys. Mode value is equal to 2. This figure indicates the highest frequency for female monkeys. Ulcerative enteritis caused by Trichomonas sp. with frequency percent of 7.4%.

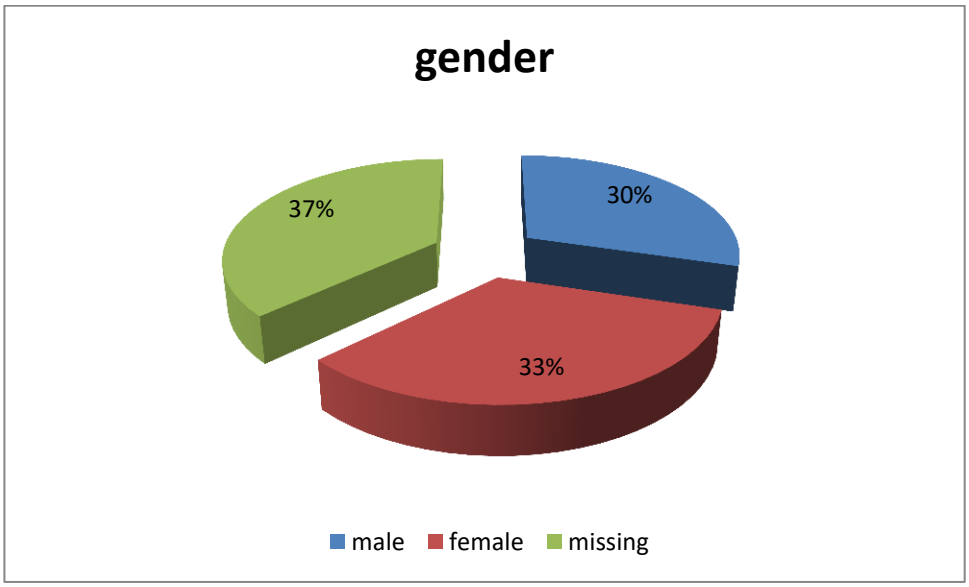


Table 4.3. Frequency Distribution based on the age of Primates

Measures	F	F(%)	Middle
< 5 years	1	3.7	3
5-10 years	3	11.1	
Adult	11	40.7	
No information	12	44.4	
Total	27	100.0	

Statistics and figures, presented in Table 4.3., show that 3.7% of the studied monkeys are less than 5 years old, 11.1% are between 5 – 10 years old, and 40.7% are adult. Also, there is no information about the age of 44% of monkeys. The middle value is equal to 3 indicating that the average age of monkeys is adult.

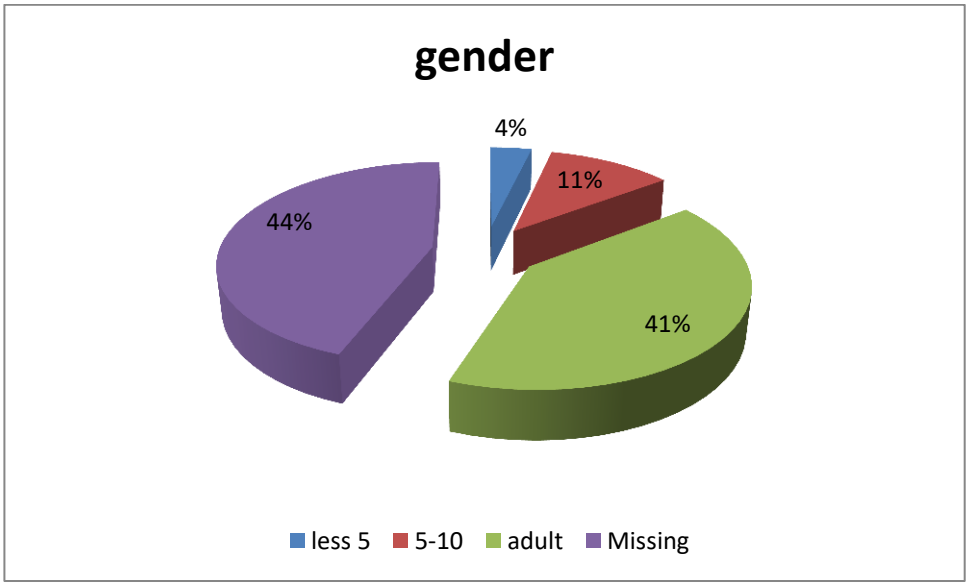
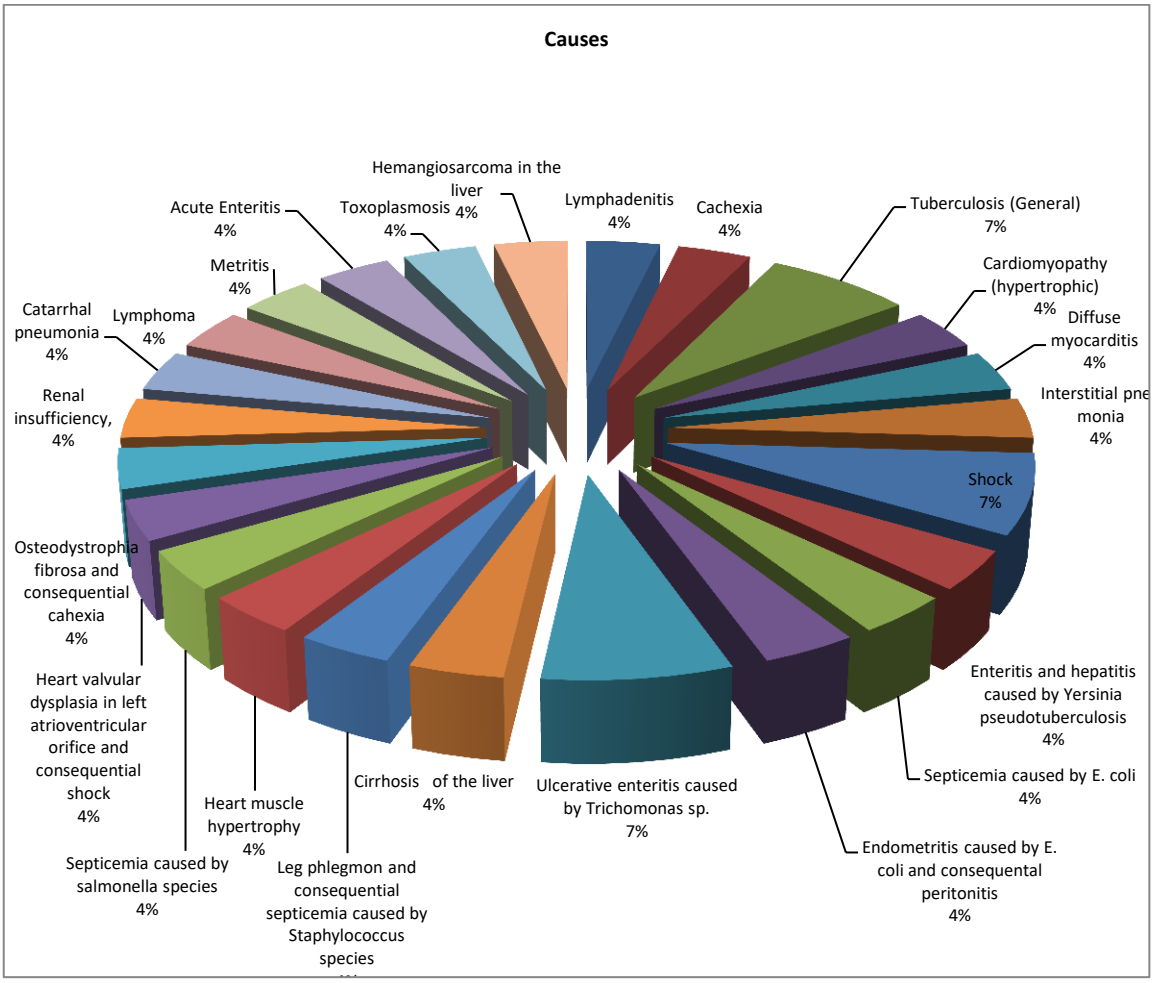
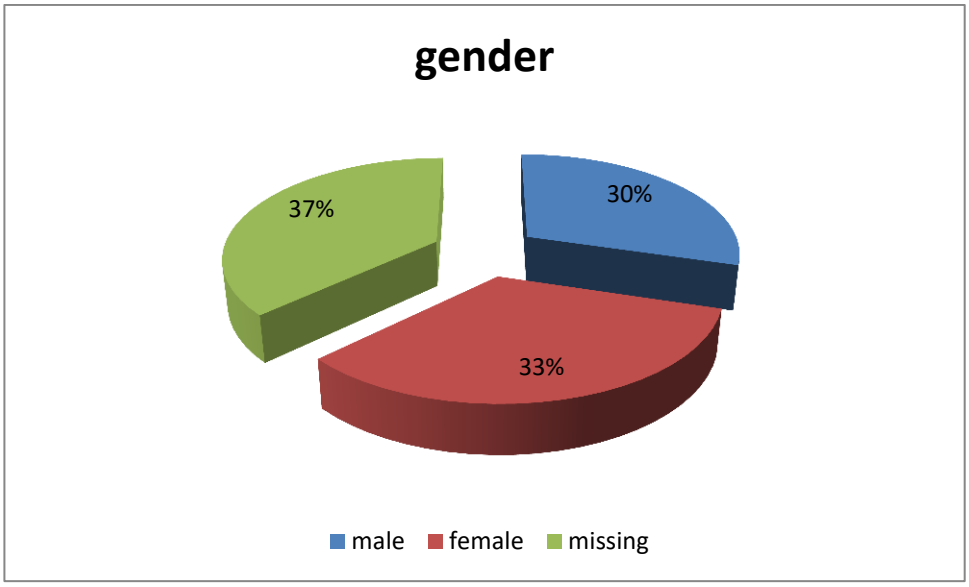

gender
4%
11%
41%
44%
less 5
5-10
adult
Missing

Table 4.4. Frequency distribution based on the cause of death in primates

Measures	F	F (%)	Mode
Lymphadenitis	1	3.7	3,7,11
Cachexia	1	3.7	
Tuberculosis (General)	2	7.4	
Cardiomyopathy (hypertrophic)	1	3.7	
Diffuse myocarditis	1	3.7	
Interstitial pneumonia	1	3.7	
Shock	2	7.4	
Enteritis and hepatitis caused by Yersinia pseudotuberculosis	1	3.7	
Septicemia caused by E. coli	1	3.7	
Endometritis caused by E. coli and consequental peritonitis	1	3.7	
Ulcerative enteritis caused by Trichomonas sp.	2	7.4	
Cirrhosis of the liver	1	3.7	
Leg phlegmon and consequential septicemia caused by Staphylococcus species	1	3.7	
Heart muscle hypertrophy	1	3.7	
Septicemia caused by salmonella species	1	3.7	
Heart valvular dysplasia in left atrioventricular orifice and consequential shock	1	3.7	
Osteodystrophia fibrosa and consequential cahexia	1	3.7	
Renal insufficiency,	1	3.7	
Catarrhal pneumonia	1	3.7	
Lymphoma	1	3.7	
Metritis	1	3.7	
Acute Enteritis	1	3.7	
Toxoplasmosis	1	3.7	
Hemangiosarcoma in the liver	1	3.7	
Total	27	100.0	

Statistics and figures, presented in table 4.4., indicate that from among the causes of death in the studied monkeys, the most common causes are Tuberculosis (general), shock and Ulcerative enteritis caused by Trichomonas sp. with frequency of 7.4%, and the other causes of death with frequency of 3.7% are the least common causes of death.





4.3 Inferential statistics

A. Investigating the relationship between species, gender and age, and cause of death among monkeys

	Rhesus monkey	Gibbon	Chimpanzee	white-headed capuchin	Macaque	Squirrel monkey	Pygmy marmoset	Ring-tailed lemur	Cotton-top tamarin	Orangutan	Guereza	Total
Lymphadenitis	1	0	0	0	0	0	0	0	0	0	0	1
Cachexia	0	1	0	0	0	0	0	0	0	0	0	1
Tuberculosis (General)	0	0	1	1	0	0	0	0	0	0	0	2
Cardiomyopathy (hypertrophic)	1	0	0	0	0	0	0	0	0	0	0	1
diffuse Myocarditis	0	0	1	0	0	0	0	0	0	0	0	1
Interstitial pneumonia	0	0	1	0	0	0	0	0	0	0	0	1
Shock	0	0	0	0	1	0	0	0	1	0	0	2
Enteritis and hepatitis caused by Yersinia pseudotuberculosis	0	0	0	0	0	1	0	0	0	0	0	1
Septicemia caused by E. coli	0	0	0	0	0	1	0	0	0	0	0	1
Endometritis caused by E. coli and consequental peritonitis	0	0	0	0	0	0	1	0	0	0	0	1
Ulcerative enteritis caused by Trichomonas sp.	0	0	0	0	0	2	0	0	0	0	0	2
Cirrhosis of the liver	0	0	0	0	0	0	0	1	0	0	0	1
Leg phlegmon and consequential septicaemia caused by Staphylococcus species	0	0	0	0	0	0	0	0	1	0	0	1
Heart muscle hypertrophy	0	0	0	0	0	0	0	0	0	1	0	1
Septicaemia caused by salmonella species	0	0	0	0	1	0	0	0	0	0	0	1
Heart valvular dysplasia in left atrioventricular orifice and consequential shock consequential shock	0	0	0	0	0	0	0	0	0	0	1	1
Osteodystrophia fibrosa and consequential cahexia	0	0	0	0	0	0	0	0	1	0	0	1
Renal insufficiency	0	0	0	0	1	0	0	0	0	0	0	1
Catarrhal pneumonia	0	0	1	0	0	0	0	0	0	0	0	1
Lymphoma	0	0	0	0	0	0	1	0	0	0	0	1
Metritis	0	0	0	0	0	0	1	0	0	0	0	1
Acute Enteritis	0	0	0	0	0	0	1	0	0	0	0	1
Toxoplasmosis	0	0	0	0	0	1	0	0	0	0	0	1
Hemangisarcoma in the liver	0	0	0	0	0	1	0	0	0	0	0	1
	1	1	4	1	3	6	4	1	3	1	1	27

Table, which is presented above, is a two-dimensional table and shows the cause of death based on the species of the studied primates' species.

To estimate the significant relationship between the species and cause of death among the monkeys, X2 test was used. The results are presented in table below.

	Results

The calculated value of x2	224/125
Degree of freedom (the number of rows-1) × (the number of columns-1)	230
sig	0/249

X2 statistics value indicates the significant relationship between the species and cause of death among the primates. In other words, there is no statistical relationship between the species and cause of death in the studied monkeys.

B. Investigating the relationship between gender and cause of death among the monkeys

	male	female	Total
Cachexia	0	1	1
Tuberculosis (General)	1	1	2
Diffuse myocarditis	1	0	1
Shock	0	2	2
Enteritis and hepatitis caused by Yersinia pseudotuberculosis	0	1	1
Ulcerative enteritis caused by Trichomonas sp.	2	0	2
Leg phlegmon and consequential septicaemia caused by Staphylococcus species	1	0	1
Heart muscle hypertrophy	1	0	1
Heart valvular dysplasia in left atrioventricular orifice and consequential shock	1	0	1
Renal insufficiency	0	1	1
Catarrhal pneumonia	0	1	1
Lymphoma	1	0	1
Metritis	0	1	1
Hemangisarcoma in the liver	0	1	1
Total	8	9	17

Table above is a two-dimensional table that shows the cause of death based on the gender of the studied primates. To investigate the significant relationship between the gender and cause of death in monkeys, X^2 test was used. The results are presented in table below.

	Results
The calculated value of x2	14/993
Degree of freedom (the number of rows-1) × (the number of columns-1)	13
sig	0/308

The statistics value of x2 shows the significant relationship between the gender and the cause of death in the studied primates. In other words, there is no significant relationship between gender and cause of death in the studied monkeys.

C. Investigating the relationship between the age and the cause of death in monkeys

	< 5	5-10	adult	Total
Cachexia	0	0	1	1
Tuberculosis (General)	0	2	0	2
Diffuse myocarditis	0	0	1	1
Shock	0	1	1	2
Enteritis and hepatitis caused by Yersinia pseudotuberculosis	0	0	1	1
Heart Muscle Hypertrophy	0	0	1	1
Heart valvular dysplasia in left atrioventricular orifice and consequential shock	0	0	1	1
Osteodystrophia fibrosa and consequential cachexia	1	0	0	1
Renal insufficiency, tubular nephritis	0	0	1	1
Catarrhal pneumonia (pneumonia Catarrhal)	0	0	1	1
Lymphoma	0	0	1	1
Metritis	0	0	1	1
Hemangiosarcoma in the liver	0	0	1	1
Total	1	3	11	15

Table above is a two-dimensional table which shows the cause of death in the studied primates based on age. To investigate the significant relationship between age and cause of death among the monkeys, X^2 test was used. The results are presented in table below.

	Results
The calculated value of x^2	26/818
Degree of freedom (the number of rows-1) × (the number of columns-1)	24
sig	0/313

The statistic value of x^2 indicates that there is no significant relationship between age and cause of death in the studied monkeys.

Multi logistic Multivariate regression analysis

To investigate the effect of the variables of species, gender and age of the primates on the cause of death in monkeys, Multi logistic Multivariate regression analysis should be used. Regression is a statistical analysis method based on which changes in one or more

dependent variables are explained and predicted compared to one or more independent variables.

Table of estimating the coefficient of determination of the regression model

Row	R^2Cox and Snell	R^2Nagelkerke	R^2McFadden
1	.991	.998	.959

The coefficient of determination of the independent variables is more than 0.9. In other words, based on the effects of the above variables, changes in the variable of cause of death in monkeys are about 0.9.

Table of regression model significance

Results	The calculated value of X^2	Degree of freedom	Sig
Final model	62.527	110	1.000

Table above is equal to ANOVA table in multiple linear regressions. In other word, the results show that whether the overall relationships of variables with dependent variable is significant or not. The statistic value of $\mathbf{X^2}$ is not significant. In other words, there is no significant relationship between dependent variables and cause of death in monkeys.

Table of regression weighted coefficient

Model factors	X^2	Degree of freedom	Sig
Species of primates	38.329	88	1.000
Gender	5.546	11	.902
Age	5.543	11	.902

In table above, the value of weighted coefficients of each variable on dependent variables is considered. The statistic value of X^2 is partially insignificant for the effect of all the dependent variables on the cause of death in monkeys.

Chapter Five

Discussion and Conclusion

5.1 Introduction

This chapter presents an interpretation of the findings provided in chapter 4. Accordingly, the present chapter provided information on the discussion of the results in the light of the previous research findings in this area and conclusions drawn from data analysis.

5.2 Conclusions

In this study, the aim was to investigate the statistical analysis of death causes of primates in Budapest Zoo during a ten years long period. The target species were included Rhesus monkey, Gibbon, Chimpanzee, white-headed capuchin, Macaque, Squirrel monkey, Pygmy marmoset, Ring-tailed lemur, Cotton-top Tamarin, Orangutan, and Guereza.

Conclusions of this study can be explained based on descriptive statistics and inferential statistics. First, according to descriptive statistics of the study, it can be said that though the animal population of the study were less than 5 years, between 5-10 years and adults, the majority of the these animals were adults and the minority were less than 5 years. It is worth mentioning that we had no information regarding the age of some of these animals. Considering the species of these primates it should be said that Gibbon, white-headed capuchin, Ring-tailed lemur, Orangutan, and Guereza had the lower frequency and Squirrel monkey had the higher frequency among others. In respect to the gender of these species, there were 8 male, 9 female and we had no information about gender of 10 of these primates.

Among the identified causes of death which were Acute lymphadenitis (Lymphadenitis), Cachexia, Tuberculosis (General), Cardiomyopathy (Hypertrophic), diffuse myocarditis, interstitial pneumonia, Shock, Enteritis and hepatitis caused by Yersinia pseudotuberculosis, Septicemia caused by E. coli, Endometritis caused by E. coli and consequential peritonitis, Ulcerative enteritis caused by Trichomonas sp., Cirrhosis of the liver, Leg phlegmon and consequential septicaemia caused by Staphylococcus species, Heart muscle hypertrophy, Septicaemia caused by salmonella species, Heart valvular dysplasia in left atrioventricular orifice and consequential shock, Osteodystrophiafibrosa and consequential cachexia, Renal insufficiency, Catarrhal pneumonia, Lymphoma,

Metritis, acute Enteritis, Toxoplasmosis, Hemangiosarcoma in the liver, the most common causes were Tuberculosis (general), shock and Ulcerative enteritis caused by Trichomonas sp., and the other causes of death were the least common causes of death.

Second, in accordance with the inferential statistics of the study, it was found that based on X2 test which was run to investigate the significant relationship between the characteristics of the population two-dimensionally, it was shown a significant relationship between the species and cause of death among the primates. In other words, there is no statistical relationship between the species and cause of death in the studied primates. Considering the relationship between the gender and the cause of death. The statistics shows that there is no significant relationship between sex and cause of death in the studied primates. As respect to the relationship between age and cause of death. The statistic value of x^2 indicates that there is no significant relationship between age and cause of death in the studied primates.

To investigate the effect of the variables of species, gender and age of the primates on the cause of death in primates, Multi logistic Multivariate regression analysis was used. The results of this analysis showed that, there is no significant relationship between dependent variables and cause of death in monkeys. And the statistic value of X^2 is partially insignificant for the effect of all the dependent variables on the cause of death in monkeys.

5.3 Discussions

Considering other studies which focused on primates and their causes of death. It is apparent that our study was one of the very few studies which embarked on the investigating the statistical analysis of death causes of primates in Budapest Zoo during a ten years long period. It seems that most studies addressed other species of primates, disease and causes of death. And in fact, no previous study has addressed the death causes of primates in Budapest Zoo, therefore, based on the aforementioned reason, only the overall result of the study can be compared with the findings of previous research.

In spite of the uniqueness of the present study, there were also studies whose focus on primates in general and disease and causes of death in particular made them suitable for comparison. For instance, one of the studies which investigated the use of NHPs in influenza was Davis, Taubenberger, and Bray (2015), who reviewed the published literature on the use of NHPs in influenza research from 1893 up to 2014.

They presented observational researches of naturally happening influenza-like syndromes in wild and captive primates, containing serologic investigations. They further provided a chronological account of experimental infections of NHPs, beginning with Pfeiffer's research and included all published studies on seasonal and pandemic influenza viruses, containing vaccine and antiviral drug testing. The third section of their study reviews experimental infections of NHPs with avian influenza viruses that have made disease in humans since 1997.

Taking into account the present study, it reveals a common point between study which is conducted by Davis, Taubenberger, and Bray, and our current study in which both studies investigated causes of death in primates.

Souza, Drexler, de Lima, and Netto (2014) seem interested in the same area we examined in our study, but the only difference is that they did not focus on the death causes of primates in Budapest Zoo and the evolutionary origins of viruses of the Hepadnaviridae family in primates was the case of their study. They had a review of the existing knowledge about the evolutionary origins of viruses of the Hepadnaviridae family in primates. They did this review by reading some articles that present information about the Hepadnaviridae virus family in non-human primates and humans and the probable origins and evolution of these viruses. The results of this study indicated that the evolutionary origin of viruses of the Hepadnaviridae family in primates has been dated back to several

thousand years; however, the lately analyses of genomic fossils of avihepadna viruses unified the genomes of several avian species have proposed a much older origin of this genus.

The authors concluded that some theories about the evolutionary origins of human hepatitis B virus have been debated since the ‘90s. One hypothesis proposed a New World origin due to the phylo-genetic co-segregation between some New World human hepatitis B virus genotypes F and H and woolly monkey human hepatitis B virus in basal sister-relationship to the Old World non-human primates and human hepatitis B virus variants. Another hypothesis proposed an Old World origin of human hepatitis B virus, and that it would have been disseminate following prehistoric human migrations over 100,000 years ago. A third hypothesis proposes a co-speciation of human hepatitis B virus in non-human primate hosts due to the closeness between the phylogeny of Old and New World non-human primate and their human hepatitis B virus variants.

Mertens, Essbauer, Rang, Schröder, Splettstoesser, Kretzschmar, and Ulrich (2011) For the purpose of examining the possible risk of natural hantavirus infection of non-human primates, studied serum samples from non-human primates of three species living in outdoor enclosures of the German Primate Center (GPC), Gottingen, located in a hantavirus endemic area of central Germany. To this end, they implied serological assays according to recombinant antigens of the bank vole (Myodesglareolus) transmitted Puumala virus (PUUV) and the common and field vole (Microtus arvalis, Microtus agrestis) related Tula virus (TULV) which are both widely geographically spread in Germany.

Eventually, their examinations indicated for the first time natural infections of non-human primates in outdoor enclosures in Germany. These outcomes confirmed the significance of hantavirus surveillance in those primate housings and parallel preventive factors against wild rodents, especially in hantavirus endemic areas. Consequently, our study can be considered as corresponding to this study by focusing on a common point of non-human primate’s disease.. All these studies focused on the specific causes of death in primates while ours is focuses on the statistical analysis of causes of death in a specific habitat (Budapest zoo here).

Abstract

Backgrounds: Zoos present a special and precious resource for primate studies. Primate species that would mostly be hard to put in situ or would cause major field study expenses can be researched in zoos. Different kinds of pure and applied subjects that might be researched in zoos are diverse and simplify intra- and inter specific comparative researches. Furthermore, most of primates live in zoos are handled in more 'naturalistic' environment in comparison with laboratories, which can present more meaningful outcomes for zoo projects.

Objectives: This study is aimed to provide an overview of the Statistical analysis of the death causes of primates in Budapest Zoo during a ten years long period of the eleven most commonly used primate genera.

Methods: Data collection process was done by taking part necropsies of dead monkeys in Budapest Zoo, Checking database of results of former necropsies and literature review of the diseases found by the necropsies.

Conclusions: based on X2 test which was run to investigate the significant relationship between the characteristics of the population two-dimensionally, it was shown that there is no statistical relationship between the species and cause of death in the studied primates. Considering the relationship between the gender and the cause of death, the statistics shows that there is no significant relationship between sex and cause of death in the studied primates. As respect to the relationship between age and cause of death, the statistic value of x^2 indicates that there is no significant relationship between age and cause of death in the studied primates.

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