

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences



Czech University of Life Sciences Prague

**Faculty of Tropical
AgriSciences**

**Analysis of university theses performed in
cooperation with selected Czech zoos**

MASTER'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled **Analysis of university theses performed in cooperation with selected Czech zoos** independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague

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Tereza Beckeová

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Abstract

Scientific research is an important part of zoo activities, next to the conservation of endangered species or education of public. This Master's thesis deals with research in zoological gardens (zoos) in Czech Republic and cooperation of zoos with academic institutions and students. Students from universities participate on projects and research in zoos as they frequently collect data for their qualification theses there. Obtained data can help the zoos to increase the knowledge of the species and set the right management and husbandry of their animals. The aim of my thesis was to analyse in more detail student theses that have been defended at selected universities and elaborated in cooperation with several Czech zoos. A more specific aim was to investigate which taxa are mostly studied and what are the main topics of these theses. It was found that qualification theses were strongly biased towards mammals, with orders Primates, Carnivora and Artiodactyla being the most frequently studied ones. Most theses were focused on Behaviour. These results are consistent with previous findings considering the quantification and qualification of zoo-based student as well as professional research. As was found, the mammalian class strongly predominates above others, concretely orders of Primates and Carnivora. Most of topics are focused on Behaviour. These obtained results correlate with worldwide situation. The present thesis also discusses what are the requirements of the zoos considering the zoo-based research. The results should help to promote meaningful research and cooperation between zoos and scientific institutions in Czech Republic.

Key words: ex situ conservation; qualification theses; student research; zoo animals

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List of the abbreviations used in the thesis

BIAZA: British and Irish Association of Zoos and Aquariums

BT: Bachelor's thesis

ČZU: Česká zemědělská univerzita (Czech University of Life Sciences)

DT: Doctoral thesis (dissertation)

EAZA: European Association of Zoos and Aquaria

JČU: Jihočeská univerzita (University of South Bohemia)

MENDELU: Mendelova univerzita (Mendel University)

MT: Master's thesis

MUNI: Masarykova univerzita (Masaryk University)

OU: Ostravská univerzita (University of Ostrava)

RIZE: Research, Internships and Zoo Education

RZSS: Royal Zoological Society of Scotland

UCSZOO: Unie českých a slovenských zoologických zahrad (Union of Czech and Slovak Zoos)

ŮJEP: Univerzita Jana Evangelisty Purkyně (Jan Evangelista Purkyně University)

UK: Univerzita Karlova (Charles University)

UPOL: Univerzita Palackého v Olomouci (Palacký University in Olomouc)

1. Introduction and Literature Review

1.1. Research as a mission of the zoos

One of the main roles of zoos and aquariums, which contribute to the conservation of nature and its diversity, is to maintain viable and sustainable ex situ populations (Welden et al. 2020). Next to the protection of endangered species or education of visitors, zoos also focus on scientific research. The research can help to gain better knowledge of the species, thus set right management of animal husbandry and improve the protection of endangered species. In recent years, there has been a growing number of publications dealing with zoo research (Kotze and Morgan 2012; Rose et al. 2014; Loh et al. 2018; Hosey et al. 2019; Kögler et al. 2020; Pyott and Schulte-Hostedde 2020; Welden et al. 2020), which demonstrates the growing effort to map and analyze the worldwide situation and support the role of zoos in science and research.

The zoos very often cooperate with scientific or academic institutions, and such a cooperation can lead to successful projects. The recent example of very close cooperation can be seen in Philippines, Palawan, where a new project was created to protect the rare and endangered binturong (*Arctictis binturong*). Memoranda of Agreements have been signed with three universities in Palawan: Western Philippines University, the Palawan State University and the Holy State University. This partnership will develop teacher-training sessions, create educational programmes about wildlife and students will also have an opportunity to gain experience by participating on conservation actions and research activities within Bearcat Study Program. The involvement of the zoo community, which participates through a variety of activities, and of researchers from the Museum National d'Histoire Naturelle (Paris, France) is also important for these conservation activities focused on binturong (Bourgeois et al. 2020).

The cooperation with zoos may be useful for students as well, as they can often collect data for their final theses there. Those data collected by students that

undertake a research theses or projects in zoos, can be used by zoos in future husbandry decisions. The changes in husbandry, enrichment or in enclosure design, that are made on the basis of student projects, can enhance standards of care, and positively affect patterns of animal behaviour (Rose et al. 2014). For students, benefits from zoo-based research are achieved via research training, which gives students opportunities to practise and develop their research skills using live animals (Rumbaugh 1971). So, this cooperation may be mutually profitable. However, it is not always effective for both sides (Fernandez and Timberlake 2008). First important step to get some more information and start to make some change is to map the current situation.

1.2. Beneficial cooperation between students and zoos

Full-time zoo curators mostly can't devote time to research as they curate animal collections, manage keeper and other staff, develop and open new exhibits, and respond to public education needs (Kleiman 1992). Even when many zoo keepers today already have a necessary education and their daily routines also include essential kind of scientific work, e.g., observing animals or record keeping (Rees 2011), in many cases they are still significantly limited by their time possibilities. Research by students or academics is therefore beneficial and some projects are highly required by zoos; especially when zoo staff has no time and capacities for performing research activities or when the projects focus on less studied taxa or topics. Bellow I will give several examples of those student projects.

1.2.1. Reducing prairie dogs aggression

The colony of the black-tailed prairie dog (*Cynomys ludovicianus*) lives in Connecticut's Beardsley Zoo, USA. In year 2014, zoo staff noticed an increasing aggression in colony (Thomas et al. 2019). Unfortunately, staff could not to prioritise behavioural monitoring and investigation of the cause due to lack of time and finance. A solution

was found thanks to RIZE program (Research, Internships and Zoo Education), which is a partnership between Fairfield University and the Connecticut's Beardsley Zoo. RIZE pairs the research needs of the zoo with undergraduate students who are interested in zoology and research.

During next 3 years students from RIZE were mapping aboveground burrow system. Then observations of prairie dog behaviour began, with higher attention to aggression, especially when and where in the enclosure this type of behaviour occurred. Burrow mapping showed that at least two groups exist in colony. Burrow mapping showed that at least two groups exist within the colony. It was found that fights because of food were the main cause of aggression. Food redistribution according to supposed groups boundaries significantly reduced aggression between animals. Those results helped zoo staff to improve future breeding management, as they develop a new feeding method which continues to alleviate territorial food aggression within the colony (Thomas et al. 2019).

1.2.2. Improving the enrichment of amphibians and reptiles

There is a lack of information in husbandry guidelines for reptiles or amphibians. The possibility to understand their behaviour in captivity is limited, as enrichment projects that enhance their psychological welfare rarely appear in the peer-reviewed zoo literature. Undergraduate degree students that have access to these animals can be used to collect data about husbandry, which can help to enhance standards of care of reptiles and increase the research output on such under-studied species. Students projects are able to add the scientific literature on reptile and amphibian husbandry requirements (Rose et al. 2014).

As in the case of captive mammals and birds, reptiles have also been shown to develop stereotypic, abnormal behaviour patterns (Young 2003). However, reptiles and amphibians can also benefit from enrichment programs that can be built into their enclosures in a manner similar to mammals and birds. Three experiments conducted by undergraduate students in Winchester, UK, were described by Paul Rose and co-

authors (2014). Those students were trained in the identification of specific behaviours and in the data collection procedure. They collected data on behaviour, activity and enclosure usage of two species of reptile (*Sauromalus ater* and *Pantherophis guttatus*) and one amphibian species (*Dendrobates tinctorius azureus*) kept in the Animal Management Centre belonging to University. Based on the results, a new enrichment was set. All three studies showed the positive responses of reptiles and amphibians to enriched environment. Significant differences in activity, space usage and also visibility were noted (Rose et al. 2014). Those cases also show that undergraduate projects of students under the professional supervision can be beneficial to zoos and help improve the animal management.

1.2.3. Research centre as a collaboration of zoo and University

Another level of really close cooperation between zoo and University can be seen in Edinburgh. In May 2008, the scientific institution 'Living Links to Human Evolution' Research Centre in Edinburgh Zoo has been opened. This institution collaborates with the Royal Zoological Society of Scotland (RZSS), the University of Saint Andrews and the Scottish Primate Research Group. Focuses on behavioural, cognitive and welfare-based research on zoo housed monkeys, also on comparative studies of children visiting the Centre, and aspects of visitor behaviour (Macdonald and Whiten 2011). All parties gain from this collaboration, as the RZSS gets a primate exposition of the highest quality and is able to promote world-class research and scientific education, and the researchers do not have to concern to husbandry and breeding but can concentrate on their scientific work. And at last, but not least, university students are involved in the research.

Since the Centre opened, within its first 3 years, over 35 different projects had been done by post-doctoral researchers, PhD and Master students, and undergraduates completing their research projects (Macdonald and Whiten 2011). All projects are approved and selected carefully, based on the academic potential and quality of the work, a hierarchy of priorities, the time scale, possible impact on current

projects, and the possibility of implementing the project. Of course, projects also need to meet the requirements of the home University, such as approval, risk assessment etc. Projects performed in a Centre focus on many different topics and deal with what currently needs to be researched.

1.3. Most frequently studied topics and animals

It is necessary to consider, that zoos began to appear just over two hundred years ago (Baratay and Hardouin-Fugier 2002), thus for the next century, zoo-based research was mostly concerned with anatomy and taxonomy (Hochadel 2011), which is understandable. In year 2008, the article from Ursula Anderson and co-authors from USA has been published. They have made an analysis and summary of 991 papers from the journal Zoo Biology within its first 25 years (from year 1982 to 2006), since the journal's founding in 1982. They didn't focus only on most frequent studied taxa and species, but also on topics of the articles and research. The field of Zoo Biology has changed significantly in the last quarter of a century. Papers on topics other than behaviour and reproduction have increased across Zoo Biology's publication history. But behaviour was the highest scoring topic (about 32 %) of papers published in Zoo Biology in its first 15 years (Wemmer et al. 1997). Papers on nutrition and infectious disease increased within the first 7 years of the journal and papers on molecular genetics, population genetics, and nutrition increased during the first 9 years. In general, however, Zoo Biology's papers concentrated on behaviour, physiology and reproduction topics (Anderson et al. 2008).

Behaviour research in zoos, which development have originated in Europe, has predominated in zoos for decades. Primarily it is because studying of animal behaviour does not require expensive equipment, observations do not require any complex manipulations which might negatively affect the specimens and the results from such studies can be directly applied to improve management of breeding and can be easily shared with other institutions (Kleiman 1992).

In year 2018, the BIAZA Research Database had been created by Geoff Hosey and co-authors, which was divided according to the author of research (zoo staff, academic staff, student) and focused on, among other, what are the main topics of research in BIAZA collections. There was a very wide range of topics in the database, but the most projects were behavioural (mainly from students; research trainings or postgraduate projects). This appears to have been a feature of zoo-based research in other zoos as well. Surveys of AZA collections also showed behaviour to be the most prominent category, with 72 % of zoos carrying out the behavioural research in 1986 (Finlay and Maple 1986) and 85 % 10 years later (Stoinski et al. 1998). The next most important topic from BIAZA was Genetics (mainly for academic researchers), Housing & Husbandry and Nutrition (Hosey et al. 2019).

As for the frequently studied taxa, many studies have consistently shown that scientific research is biased towards mammals. In BIAZA Research Database (2019) mentioned above, there was a huge amount of student projects on Primates and Carnivora (Figure 1), with substantial number of projects also on Proboscidea, Cetartiodactyla and Perissodactyla (Hosey et al. 2019). On the other hand, reptiles and amphibians are not common subjects of studies and researches (Rose et al. 2014).

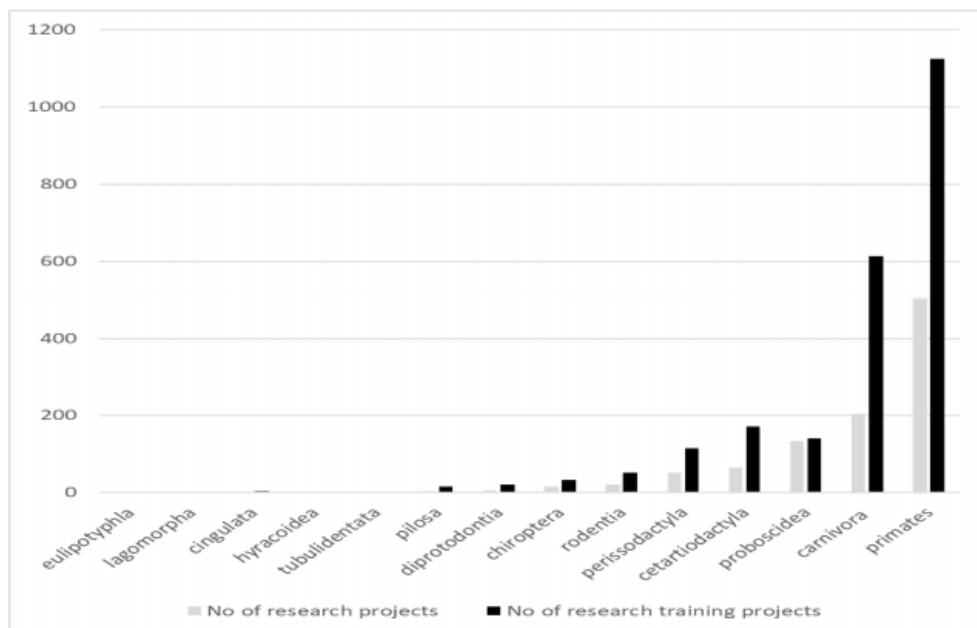


Figure 1 (The most frequently studied mammalian orders in BIAZA collections)

Source: Hosey et al. 2019

1.4. The trend of charismatic megafauna

The body size and the attractiveness of mammals play significant role. Visitors come to zoos mainly for recreational activities and they expect to see large, attractive, and active animals (Frynta et al. 2013). Measuring of animal popularity still yielded the conclusion that larger animals are more popular, especially with children (Ward et al. 1998). On the other hand, larger animals are more expensive to maintain in zoos than are smaller animals, and they breed at slower rates. So, the zoos could potentially contribute more to conservation efforts by concentrating on smaller-bodied species, but they could lose support of zoo's public, if the public prefers to see larger species. Mostly nobody (from laic public) is interested in an animal which is unknown, which seems „ugly“ or which is most of the time hidden and not visible well. The research attention may be also given only to certain animal species. However, small, non-popular or less-known species, which can be continually overlooked, need a research and protection as well.

To some extent, it is caused by the trend called „charismatic megafauna“; a long-term interest of people (laic public even the researches) only in big, famous, favourite animal species. There are many animal species which can be found mostly in every zoo across the world. Society can see them and meet them regularly and of course people like them. Through the time, those animals became favourites, an icon, a symbol. In logos, posters, souvenirs, they are just „famous“.

In conservation, the role of charisma may be important in public communication and the funding process. As people are naturally attracted to charismatic species, they are more willingly fund conservation programmes focusing on such species. Consequently, the public may underappreciate biodiversity or overlook non-charismatic species in need of conservation attention (Albert et al. 2018). On the other hand, there is also evidence, that the popularity of some animals actually helps zoos to achieve their conservation mission, both by increasing funding available for field conservation and by contributing towards education and awareness raising of conservation issues (Hosey et al. 2020).

As mentioned, the problem of prioritizing some species occurs in education and research field as well, as evidenced for example by the number of scientific publications which investigate the welfare of charismatic rather than non-charismatic species. (Hosey et al. 2020) compared three charismatic taxa (elephants, great apes and cetaceans) with three similar non-charismatic taxa (tapirs, gibbons and manatees) from the point of view of how frequently they are mentioned in welfare-related stories in the media, how much scientific research is undertaken on their welfare and how many of them are housed in zoos (Hosey et al. 2020). The first group had been preferred more often. However, many more studies focused on the problematic of attractive megafauna have been done already.

Due to the above-mentioned trends, the cooperation between zoos and academic institutions may be not always effective (Fernandez and Timberlake 2008). Many students but also a lot of scientists are interested only in attractive animal species and in many theses even in professional research, still the same species are searched. First important step to get more information about the current research activities and eventually to start making some changes is to map the current situation.

2. Aims

The aim of the present thesis is to analyse in detail the qualification theses (Bachelor's, Master's and dissertation) defended at selected Czech universities and elaborated in cooperation with Czech zoos (members of UCSZOO). More specific goals are to investigate which taxa are studied and which topics are studied. The aim of the thesis is also to discuss the obtained results with respect to the current research requirements raised by zoos.

3. Methodology

To establish a database of university theses I reached a publicly available online repositories of eight selected universities known for their biological focus. Table 1 present the list of these universities, their location, and the link to the repository.

Table 1 (List of searched universities)

Czech name of the university (abbreviation), English name	Location	Link to the repository
Česká zemědělská univerzita (ČZU), Czech University of Life Sciences in Prague	Praha	https://is.czu.cz/zp/
Univerzita Karlova (UK), Charles University in Prague	Praha	https://is.cuni.cz/webapps/zzp/search/?tab_searchas=basic&lang=cs
Jihočeská univerzita (JČU), University of South Bohemia	České Budějovice	http://invenio.nusl.cz/collection/Jihočeská%20univerzita%20v%20Českých%20Budějovicích?ln=cs
Mendelova univerzita (MENDELU), Mendel University in Brno	Brno	https://is.mendelu.cz/zp/?lang=cz
Masarykova univerzita (MUNI), Masaryk University in Brno	Brno	https://is.muni.cz/thesis/
Univerzita Palackého (UPOL), Palacký University in Olomouc	Olomouc	https://library.upol.cz/i2/i2.entry.cls?ictx=upol&src=upol_us_cat-17
Univerzita Jana Evangelisty Purkyně (UJEP), Jan Evangelista Purkyně University	Ústí and Labem	https://arl.ujep.cz/arl-ujep/cs/rozsirene-vyhledavani/
Ostravská univerzita (OU), University of Ostrava	Ostrava	https://portal.osu.cz/wps/portal/dipl

A period of 10 years (2009-2019) has been specified, from which the theses were analysed. All repositories were searched by using keywords, mainly: „zoo“; „zoo research“; „captive“; „captive“; „human care“ and names of the zoos („zoo Olomouc“; „zoo Hluboká“ etc.). The same keywords were gradually inserted into all repositories to maintain the possibility to get as many results as possible from all of them. Additional theses were found at the web portal Theses.cz using the same keywords, and in Annual Reports of some zoos (not every zoo has a list of performed theses). Only Czech zoos which are the members of UCSZOO were included in the database (16 zoos). Some theses were written in cooperation with Czech and foreign zoos (Slovakia, Germany, Austria and others), these zoos are not considered in the database. If the thesis was written only in cooperation with a foreign zoo, the thesis is not included at all.

The theses were included in the database if the author performed her/his own observation at the zoo, collected data at the zoo, communicated with zoo staff or performed questionnaires for visitors. This was usually mentioned or explained in Acknowledgements/Abstract/Methodology chapters of each thesis and could be evaluated by using the searching tool. Selected theses were added to the Excel.

The database contained the title of the theses, information on partitioning zoos (one specific zoo or multiple zoos), type of the theses (Bachelor's, Master's, dissertation), at which university and at which year the theses were defended. The theses were further classified according to several criteria. The first criterium was the general aim of the thesis and 10 categories were identified (Table 2).

Table 2 (General aim classes of selected theses)

Aim (number of theses)	Description (title of thesis as an example)
Architecture (1)	Focused on some buildings and architecture located at the zoo (e.g., <i>Svatyně jako součást expozice zoologické zahrady: Případ Zoo Praha</i>)
Education (17)	Focused on using zoo as an environment for education of school children (e.g., <i>Podíl ZOO Zlín na vzdělávání a popularizaci biologie/ Stezka v ZOO Ohrada - pracovní listy pro žáky 2. stupně</i>)
Legislative (4)	Focused on law and legislation in zoos (e.g., <i>Právní úprava provozování zoologických zahrad</i>)
Management (8)	Focused on tourism, zoo management and administration (e.g., <i>Management atraktivity cestovního ruchu: ZOO Chleby/ Krizová připravenost vybrané zoologické zahrady</i>)
Marketing (1)	Focused on marketing of the zoo (e.g., <i>Marketing communication in Prague zoo</i>)
Media (5)	Focused on media and medial communication of zoos (e.g., <i>Mediální obraz pražské ZOO/ Komunikace ZOO Praha po povodních 2002</i>)
Vegetation (4)	Focused on vegetation and maintenance of green in zoos (e.g., <i>Inventarizace zeleně v zoologické zahradě v Ústí nad Labem a návrhy nových sadových úprav</i>)
Visitors (15)	Focused on visitor, their satisfaction, opinions, or awareness (e.g., <i>Povědomí návštěvníků zoo o enrichmentu/ Zoo here and there: Observation of Visitor Behavior in the Prague and Reykjavík Zoos</i>)
Zoo (7)	Focused more on general topic, role and mission of the zoo, comparison of zoos (e.g., <i>Poslání moderních zoologických zahrad/ Srovnání vybraných zoo v ČR</i>)
Zoology (234)	Focused on animals that are kept and bred at the zoos. Further classification of these theses is stated in Table 3.

Only theses from the category of Zoology were further classified and analysed. According to their topic, they were classified into 13 categories (Table 3). After that, the taxonomy coding has been performed. For each thesis was determined, which Class, Order, Family, Genus and Species it is aimed at. In case of theses focused on

more than one taxon, the coding is "multiple" at the specific taxonomic level and the thesis is not further classified. Some genera (*Diceros/Ceratotherium/Rhinoceros*), and some species (*Elephas maximus/Loxodonta africana*; *Colobus angolensis/Colobus guereza*; *Pan troglodytes/Pan paniscus*; *Pongo pygmaeus/Pongo abelii*) were merged into one category. Giraffe was also taken as one species (*Giraffa camelopardalis*).

Table 3 (Topics of selected theses from Zoology aim class)

Aim category (number of theses)	Description (title of thesis as an example)
Behaviour (79)	Focused on behaviour, social interaction of animals, communication, activity, ethology (e.g., <i>Chov surikat v Zoo Dvůr Králové - sociální chování a aktivita/ Vztah mezi matkou a mládětem v kolonii kaloňů egyptských Rousettus aegyptiacus v ZOO Praha</i>)
Collection (4)	Focused on zoo collections (e.g., <i>Obratlovci Madagaskaru v České republice/ Chov a odchov hadů v českých zoologických zahradách – analýza trendů</i>)
Conservation (7)	Focused on threat, conservation programs and reintroduction (e.g., <i>Ohrožení tygra ussurijského Panthera tigris altaica ve volné přírodě a jeho záchranný chov v zoologických zahradách České republiky</i>)
Ecology (5)	Focused on zoos as a living space for wildlife and free-ranging species that are not a part of the collection (e.g., <i>Hnízdní bionomie vybraných druhů pěvců na území ZOO Ostrava/ Dynamika populací škůdců v krmivech a chovech zvířat v Zoo Praha</i>)
Genetics (18)	Focused on genetic variability, diversity and analyses (e.g., <i>Kůň Převalského jako významný genetický zdroj a nebezpečí inbreedingu pro jeho chov/ Analýza mikrosatelitových lokusů pro determinaci paternity u volavčíka člunozobého</i>)
Health & body condition (10)	Focused on health condition, body scoring or factors influencing health (e.g., <i>Sledování původce chytridiomykózy u obojživelníků v České republice a na Balkánském poloostrově/ Factors influencing weight fluctuation in giraffids</i>)

Husbandry (32)	Focused on biology, strategy and evaluation of husbandry (e.g., <i>Zhodnocení chovu denních lemurovitých v zoo Jihlava/ Smíšené expozice kopytníků v zoologických zahradách</i>)
Morphology (6)	Focused on anatomy, body difference, and growth (e.g., <i>Variabilita tvaru krunýře u vybraných zástupců čeledi Geoemydidae/ Sledování růstové schopnosti mláďat slona indického chovaného v ZOO Ostrava</i>)
Nutrition (22)	Focused on nutrition, food composition, feed rations or digestive tract (e.g., <i>Vliv změny krmné dávky na populace střevních nálevníků u šimpanzů v zajetí/ Stanovení živinových potřeb pro chov vysokohorských koz v zoologických zahradách</i>)
Parasitology (7)	Focused on parasites and caused diseases (e.g., <i>Endoparazité v chovech žiraf v Zoologických zahradách v České republice</i>)
Physiology (4)	Focused on physiology and body functions (e.g., <i>Termografická analýza teploty povrchu těla a teploty okolního prostředí u soba polárního</i>)
Reproduction (19)	Focused on fertility, reproduction, rearing of young, nesting (e.g., <i>Umělý odchov vybraných skupin ptáků v zoo/ Neinvazivní monitoring hormonů z trusu gepardích samic</i>)
Welfare & enrichment (21)	Focused on welfare, enrichment and its influence in breeding (e.g., <i>Vyhodnocení welfare expozice v zoo Hluboká/ Potravní enrichment u vybraných zástupců čeledi Felidae</i>)

Data were prepared for further analyses in the form of several frequency tables. These tables were used to test whether the number of theses significantly differed with respect to their type, zoo, aim category, animal class and mammalian order. Chi-square test was used for this purpose and Fisher's exact test was used for post hoc comparisons. For eleven zoos the ratio of theses performed in cooperation with one specific zoo and theses performed in cooperation with the same as well as other zoos was calculated. Statistical softwares STATISTICA v. 8. 0 (StatSoft, Tulsa, OK, USA) and R v. 3. 6. 3 (R Core Team 2020) with the use of the package rcompanion. Results were considered significant when $p < 0.05$.

4. Results

The database contained 296 theses in total. Their number culminated in years 2014 – 2015 (Figure 2). There is significant difference in the number of Bachelor's, Master's, and dissertation theses ($\chi^2 = 81.07$, $p < 0.001$). The number of dissertation theses (13; most in year 2016) was significantly lower ($p < 0.001$) than the number of Bachelor's theses (143; most in year 2015) and Master's theses (140; most in year 2014), while there was not a significant difference between the number of Bachelor's and Master's theses ($p = 0.90$).

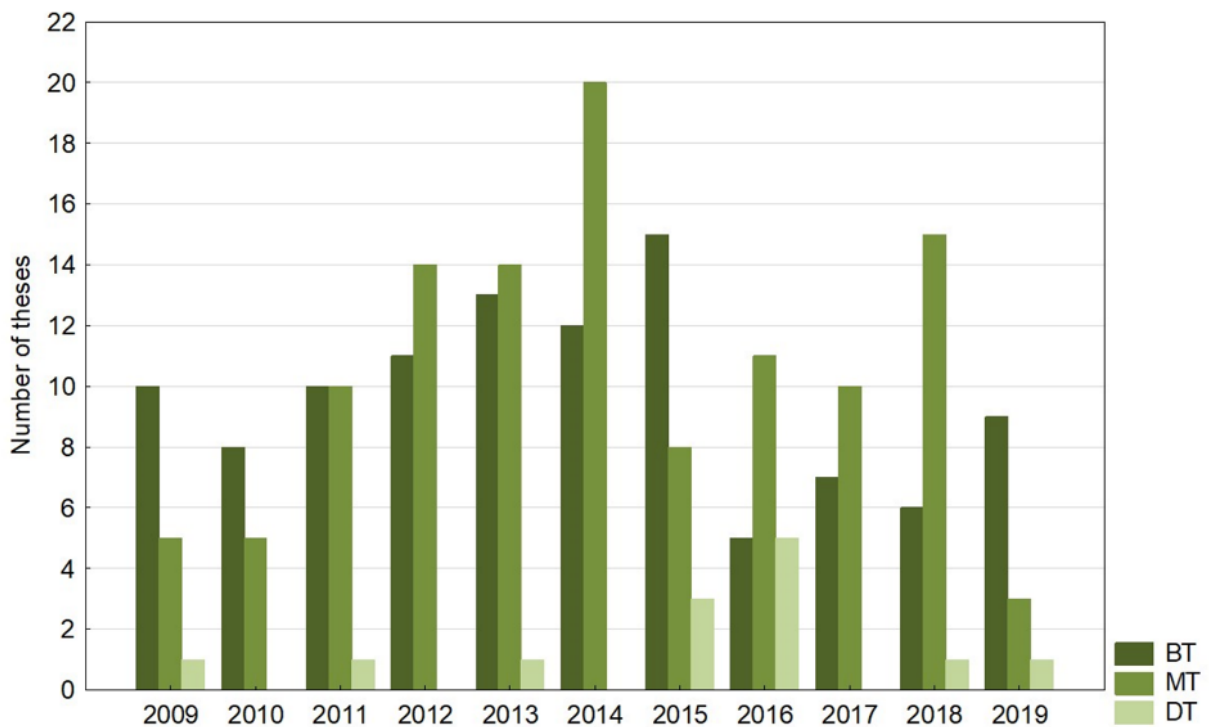


Figure 2 (The number of theses defended from 2009 to 2019)

BT = Bachelor's thesis, MT = Master's thesis, DT = dissertation thesis

The highest number of theses was performed in cooperation with the Zoo Prague (126), followed by Dvůr Králové (57), Olomouc (57), Ostrava (53), Brno (46) and other zoos (Figure 3). There was a significant difference only between the Zoo Prague and Zoo Dvůr Králové ($p < 0.05$). The Figure 3 includes all zoos, but in following analyses, the zoos with total number of performed theses lower than 20 were not included (namely Děčín, Hodonín, Chleby, Chomutov and Vyškov). The small sample size would be not adequately comparable to large zoos with a much larger number of theses performed.

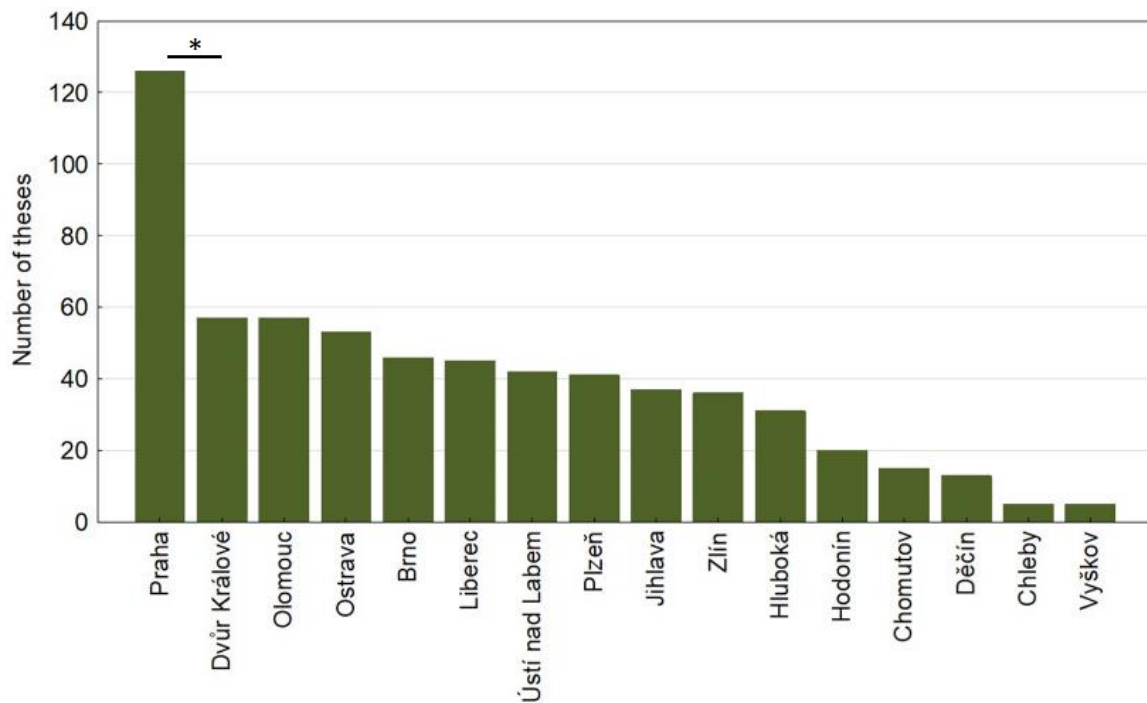


Figure 3 (The number of theses performed in individual zoos)

* Significant difference ($p < 0.05$)

However, there is a difference in order when considering the number of theses that were written in collaboration only with one zoo in relation to the total number of theses performed in that zoo (Figure 4). In this case there was the highest number of theses in Hluboká zoo (16 single theses from 31, which is over the half).

Zoo Prague follows with 50 single theses from 126 and Dvůr Králové (15 theses from 57).

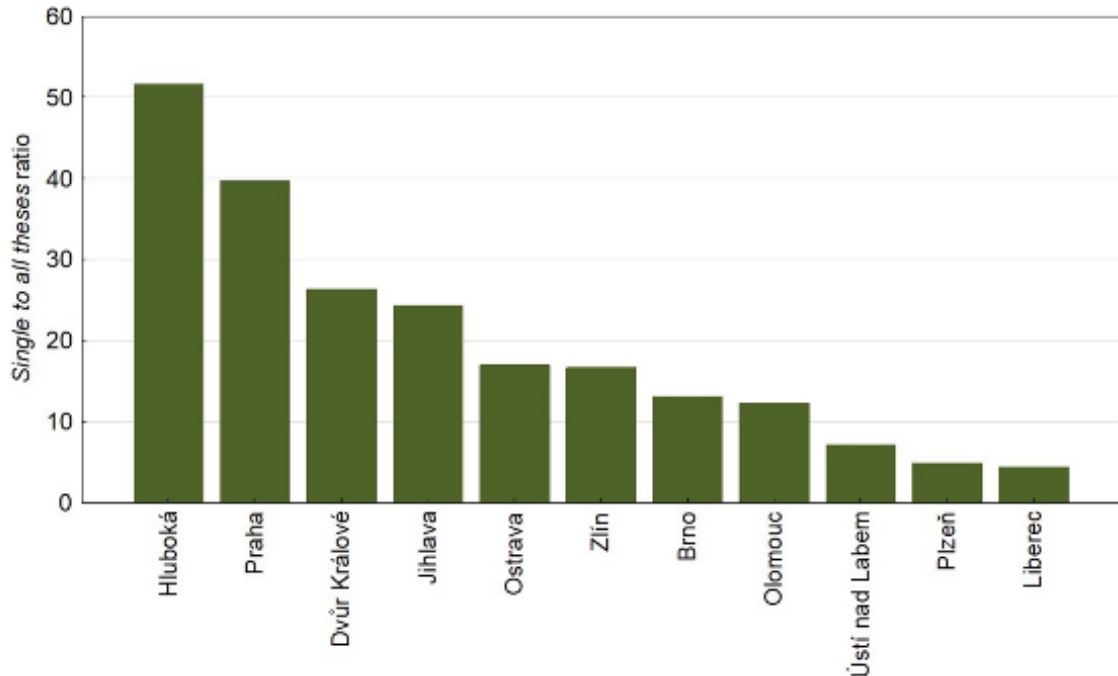


Figure 4 (Ratio of single to all theses)

Considering the eight studied universities, students from most of them cooperated with all zoos in Czech Republic, however there are stronger bonds between some universities and zoos according to their locality and distance (Figure 5). This relationship is well visible for example in case of Hluboká zoo, where most of the theses was performed by JČU from České Budějovice. MENDELU university was cooperating mostly with zoos in Brno and Zlín. Of course, Charles University (UK) took the biggest part in Zoo Prague as both institutions are located in Prague. On the other hand, in some zoos, cooperation with the UK is not recorded at all (Hluboká, Liberec, Olomouc, Ostrava and Zlín). However, ČZU, which is also located in Prague, cooperates with several zoos. Further we can notice details like higher number of theses from OU performed in Ostrava zoo or from UJEP in zoo Ústí na Labem.

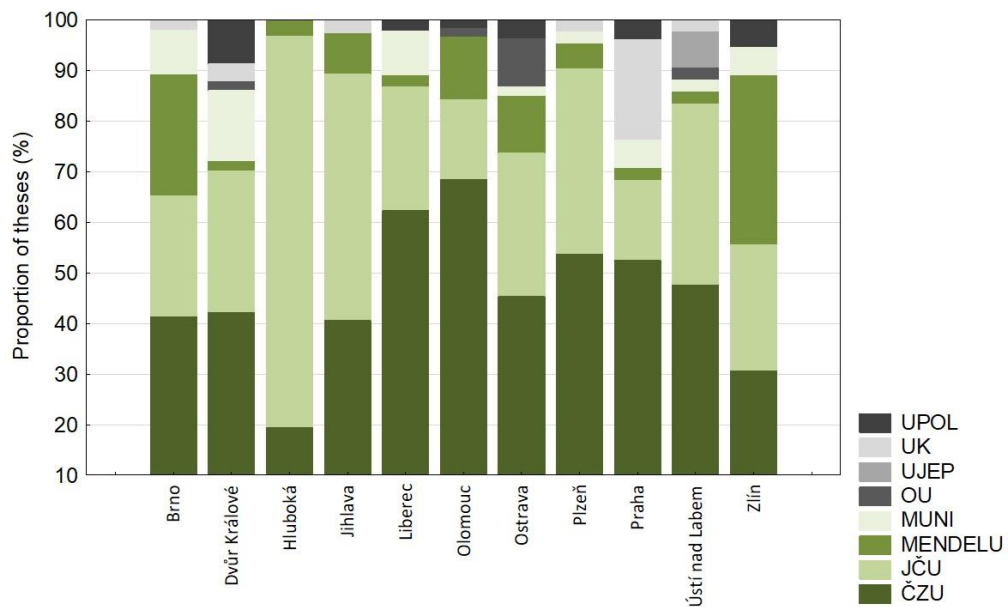


Figure 5 (Ratio of university theses from each university in zoos)

Abbreviations of universities explained in the List of the abbreviations

In Figure 6, there are most frequently researched topics in the zoos in Czech Republic. The most frequently studied topic (from 13 determined from Zoology category; 234 theses) was Behaviour targeted by 34 % (79 theses), followed by 14 % of theses aimed on Husbandry (32 theses). There was a significant difference between first two topics ($p < 0.05$). Next most frequent topics were Nutrition (22 theses) and Welfare & enrichment (21 theses).

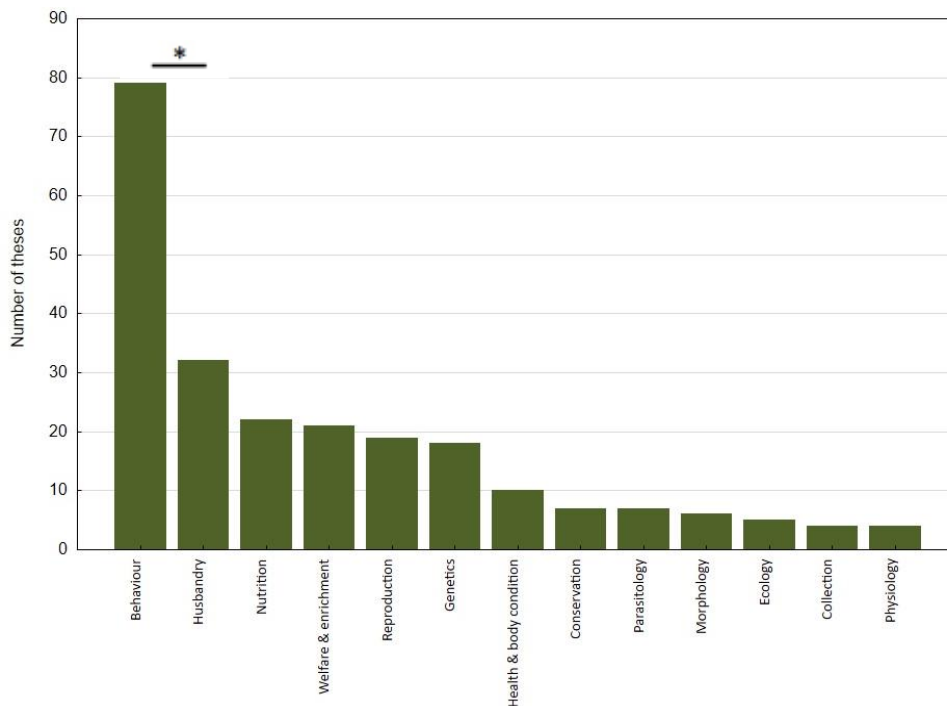


Figure 6 (The number of theses devoted to individual topics)

* Significant difference ($p < 0.05$)

In Figure 7, there is a ratio of all 13 classified topics studied in individual zoos. Behaviour or Husbandry occur most often in all of them. In Hluboká zoo a substantially large part of the theses were focused on Welfare & enrichment.

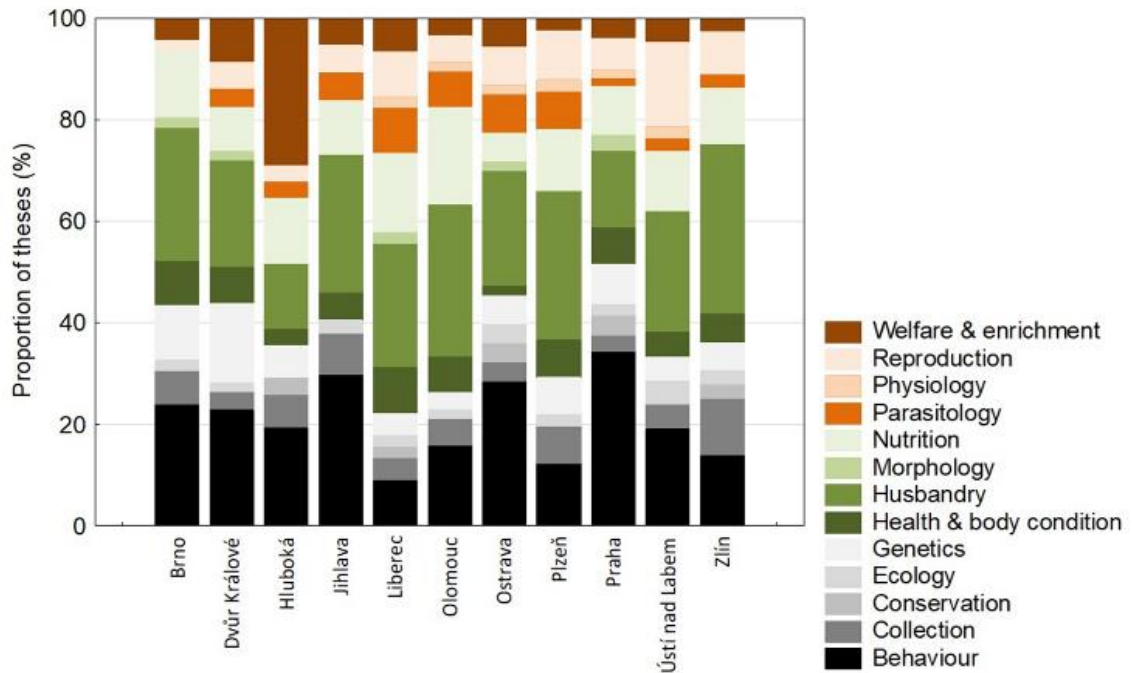


Figure 7 (Ratio of all topics studied in individual zoos)

The most studied class were mammals (Figure 8), which were targeted by 83 % of the theses. Far behind them are the birds (9,8 % of the theses), and reptiles (3,8 % of the theses). Only 1 thesis was performed on amphibians, 1 on arachnids and 7 theses belong to the category Multiple. In ratio of classes studied in zoos (Figure 9), there are almost no differences between zoos. Just a bit more theses focused on birds was in zoos Hluboká and Zlín.

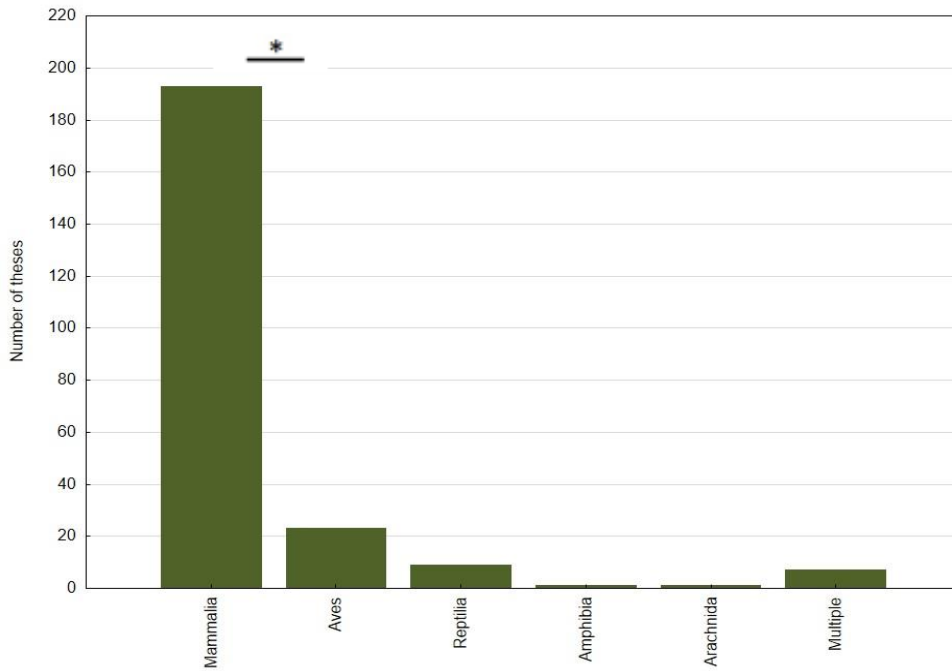


Figure 8 (The most frequently studied classes)

* Significant difference ($p < 0.05$)

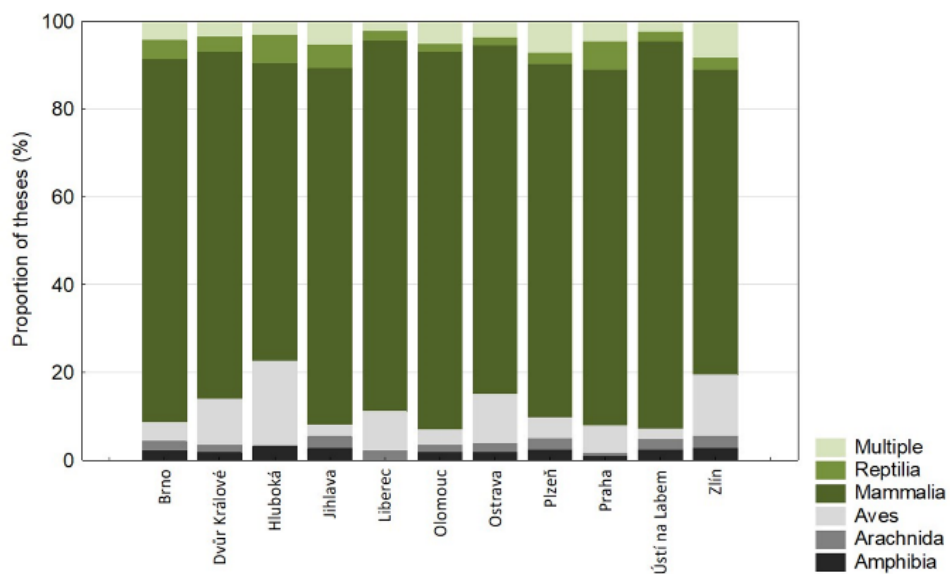


Figure 9 (Ratio of classes studied in zoos)

As mammals are the most frequently studied class, next analyses already have been done only for mammals. There are orders that are studied most often across all zoos (Figure 10). Those orders are Primates (59 theses), Carnivora (53 theses) and Artiodactyla (40 theses). Other orders, which more than 10 theses dealt with, are Perissodactyla (14 theses) and Proboscidea (11 theses). There was no significant difference between the first three orders, this difference occurs between Artiodactyla and Perissodactyla ($p < 0.05$).

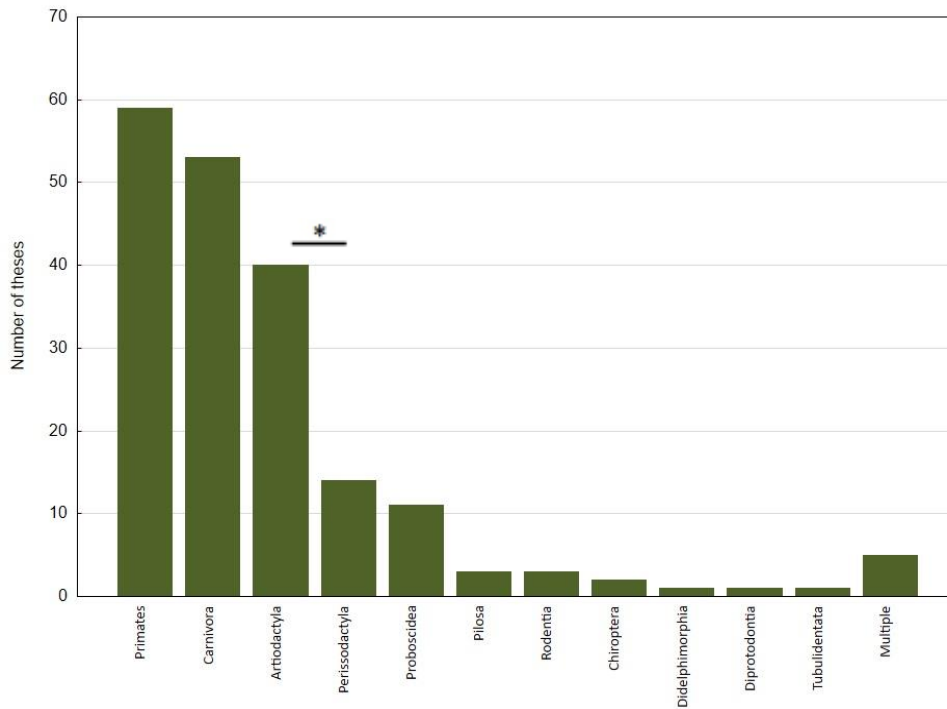


Figure 10 (The most frequently studied mammalian orders)

* Significant difference ($p < 0.05$)

Figure 11 displays the ratio of orders studied in individual zoos. Larger number of theses focused on Perissodactyla was performed in Zoo Prague and in Zoo Dvůr Králové, more theses focused on Proboscidea can be found in Zoo Ostrava.

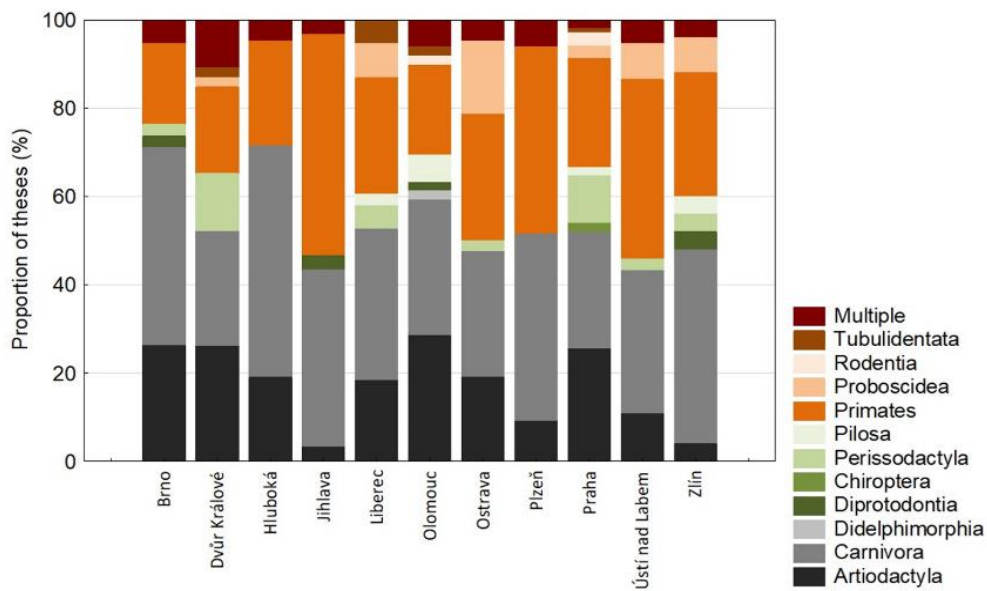


Figure 11 (Ratio of orders in individual zoos)

A total number of 51 studied mammalian species were identified, those that were the focus of at least 3 theses are shown in Figure 12. As lot of theses was aimed on multiple species (or even multiple families or orders), the most of them was not possible to encode according to the one species. However, from those which were really aimed only on one species, we got following results. *Elephas maximus* and *Loxodonta africana* were counted in one category and they are on the first place (11 theses) together with *Giraffa camelopardalis* (11 theses as well). Next most frequently studied species are *Equus przewalskii* (8 theses) and *Gorilla gorilla* (8 theses). Less than 10 theses were aimed to next species but following 13 species in graph belong to orders Carnivora, Primates or Artiodactyla, which corelates with the results of most frequently studied mammalian orders.

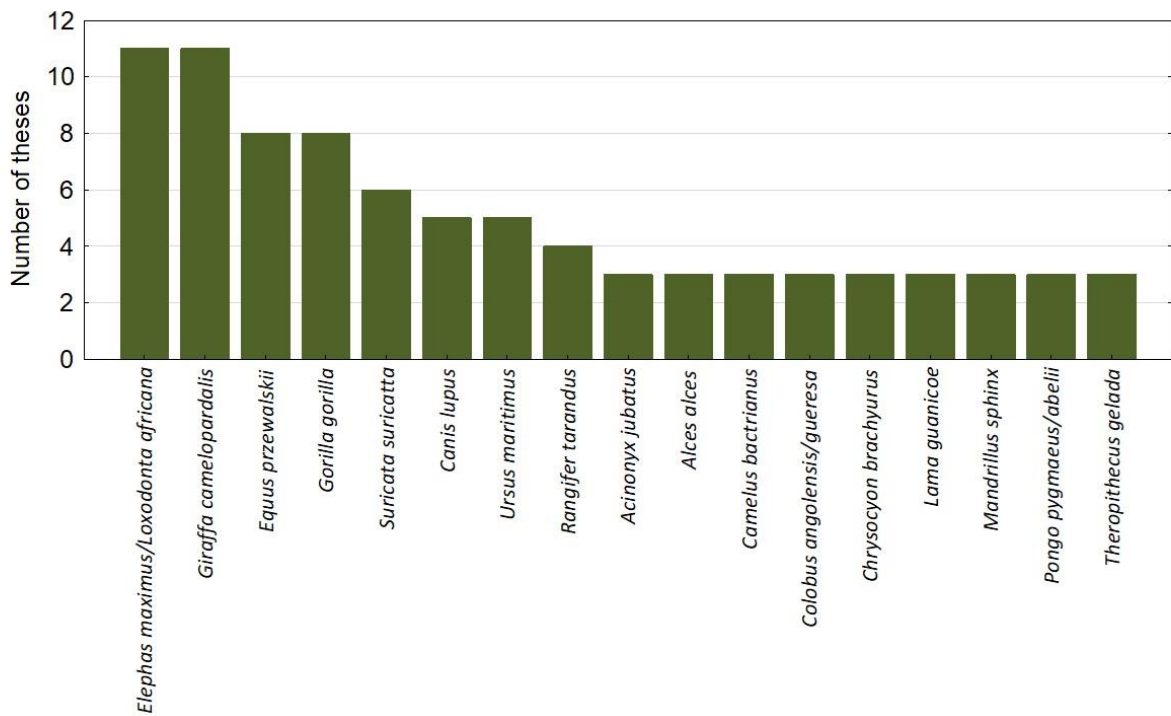


Figure 12 (The most frequently studied mammalian species)

5. Discussion

The present thesis shows that all Czech member zoos of UCSZOO cooperate with universities regarding student research and students frequently collect data for their theses at these institutions. All the studied universities were involved in such cooperation. Although it can be expected that VFU (Veterinární a farmaceutická univerzita Brno/University of Veterinary Sciences Brno) also strongly cooperates with Czech zoos, there is no online repository, therefore I did not include this university in my database. I preferred this approach to create the database to direct communication with institutions (universities or zoos), because the communication would be probably unbalanced (some institutions cooperating while others not). Thus, there could be significant differences between the data obtained, which would bias the results of the analyses.

Although the relationship between the zoos and the universities was not statistically tested in this thesis, it is clear that some universities have significant links to closely located zoos. This relationship according to the distance is well visible for example in case of the Prague Zoo and the Charles University, the Hluboká zoo and the University of South Bohemia in České Budějovice (JČU), or in the case of the MENDELU university, which was mostly cooperating with zoos in Brno and Zlín.

It is also necessary to consider that it is problematic to reach the perfect database containing all defended theses from the selected period. Despite the searching effort, there will be always some theses which may stay hidden to us or which are not available online (so it was not possible to determine whether they really deal with research at the zoo). However, this probably did not significantly affect our results and including additional theses would not probably significantly affect our general conclusions. Anyway, for further evaluation and completing of similar databases it would be useful to use accurate titles and to index the theses by appropriate key words. The cooperation with zoos could be also highlighted in Acknowledgements. Additionally, the theses should be well accessible and easy to find.

Another important fact is that in the end, different numbers of theses from each university were obtained and included. This should be taken into account when comparing the ratio of theses from universities performed in individual zoos. It may seem, that some universities (ČZU, JČU) performed theses in every zoo, while other universities (OU, UJEP, UPOL) in some zoos are not represented at all; however, there is also a lower total number of theses from those universities in the database.

The majority of the theses was performed by bachelor or master students; the number of dissertations is significantly lower. Doctoral students may avoid research in zoos, because higher demands are often placed on their dissertations, and they may face various challenges when performing their research in zoos; for example, small sample sizes, the deficiency of independent observations that are necessary for statistical analyses, or potential impact of captive conditions on natural behaviour of animals (Hosey et al. 2013; Kuhar 2006; Reese 2013).

The results of the present thesis show that the theses performed in cooperation with zoos are aimed on various topics like Management, Education or Visitors, however, the majority is focused on Zoology and the animals themselves. The most frequently studied animal class by Czech students are mammals, while reptiles, amphibians or even fish, which are also commonly kept in zoos, seem to be very overlooked classes in zoo-based research. There was no thesis aimed on fish noticed. These results correspond to results of other authors and trends that have been found worldwide (Anderson et al. 2008; Hosey et al. 2020). It is interesting, that a lot of theses analyzed in the present study is focused on carnivores, while peer-reviewed zoo-based research focused on carnivores is basically missing in the Czech Republic (Schneiderová, unpublished results). This may suggest that the topics of the final theses are often based on the choice of the students themselves and their preferences, thus, based on the attractivity of the animals. In the case of more frequently studied orders in relationship to concrete zoos, larger number of theses focused on Perissodactyla was performed in Prague zoo, where *Equus przewalskii* is kept, and in zoo Dvůr Králové, where the theses were focused on Equidae and Rhinocerotidae families. Both zoos are very successful in *in-situ* conservation of mentioned species, in addition, the Prague Zoo is famous for the long-term breeding of

Przewalski's horse and by keeping its international studbook. This species became a symbol of successful conservation of a species in the human care (Volf 2002). Those aspects may be very attractive for students, when looking for a subject of their thesis.

Next results show that the most frequently studied topic in Czech zoos is Behaviour. That also corresponds to world and long-term trends. Behaviour research in zoos predominates for decades, primarily because observation and studying of animal behaviour does not require any expensive equipment, contribute positively to the long-term breeding programs and conservation biology, and the results from such studies can be directly applied to improve the animal management (Kleiman 1992). However, for example, genetic studies are very important for zoos, as they allow correctly determine the species, subspecies, or eventually genetic relatedness of individuals (which can help to prevent inbreeding and related problems). Nutrition studies are also needed; for example, in case of the moose (*Alces alces*) or maned wolf (*Chrysocyon brachyurus*), as those species have specific nutritional requirements, so their successful breeding can be challenging (Schneiderová 2019).

To some extent, zoos identify and highlight their research requirements. Most Best Practice Guidelines published by EAZA, in addition to combining expert husbandry knowledge for many animal species and helping with decision-making in breeding management, also contain chapter on research requirements. There is a recently published guideline for the Noble chafer (*Gnorimus nobilis*), which is not usual species to exhibit in a zoo, but it is a symbol of the strong insect decline, and it therefore plays the lead role in a conservation project of Copenhagen Zoo. The Guideline also includes a Recommended research chapter, which say, there is a great lack of information on *G. nobilis*. Further research would be extremely useful for future conservation planning and management of the species. The studies on lifecycle, substrates' effect on growth, optimal densities for captive breeding, or investigation of potential negative effects of inbreeding are highly needed or planned to be carried out in the nearest future. More detailed field studies are needed as well (Ellegaard and Bach 2020). Recently, scientific workers and researchers have been hired to conduct and develop research activities in many zoos. This could also help to steer the zoo-based research in the required direction. At the same time, the theses of students should be also professionally and

carefully supervised by universities, to ensure their quality and potential scientific contribution.

6. Conclusion

Next to the conservation of species or education of visitors, the research is very important part of zoos activities and aims. As the research is supposed to be beneficial to zoos, it may be equally devoted to all species and topics. The zoos often cooperate with academic institutions, which means that students can collect data for their final theses, or they can participate in research and projects performed in zoos. So, the cooperation may be mutually profitable, especially in case that the required species and topics are searched. Main aim of my thesis was to map the current situation of student zoo research in Czech Republic. The data obtained through online available repositories of eight selected universities were analysed and the results significantly correlate with situation in Europe even in the world. The theses performed in last 10 years are most often focused on Behaviour and Husbandry topics. The most studied class are mammals, which strongly predominates. The most of theses aimed on Primates, Carnivora and Artiodactyla, but we can also notice some trends like one of the most frequent studied species, which is *Equus przewalskii*, kept in Zoo Prague. This thesis points out that cooperation between zoos and academic institutions may be enhanced and improved. Zoos should be able to clearly formulate their research requirements and students should be more supported to focus on less attractive and overlooked taxa and topics, which need a research.

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