Comparing the behaviours before and after enriching the aviary of: Common raven (*Corvus corax)*, kea (*Nestor notabilis)* and great white pelican *(Pelecanus onocrotalus).*

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Eigenständigkeitserklärung

Ich erkläre hiermit, dass ich die vorliegende Bachelorarbeit selbständig unter Anleitung verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe.

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(Datum) (Felix Braun)

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ABSTRACT

For many centuries humans are keeping animals in captivity. In the beginning exotic animals just were housed for pleasure and entertainment. However, the awareness of humans has changed during time and animals are more often subjects for research and education in the focus of zoological gardens. The resulting knowledge is used for optimising the housing conditions, whereby the welfare of the animal should be increased. For this, animal behaviours are seen as good indicators.

In this thesis it will be investigated if and how far physical enrichment influences the behaviours of common raven (*Corvus corax*), kea (*Nestor notabilis*) and great white pelican (*Pelecanus onocrotalus*) living in captivity at Zoo Heidelberg. A focus is set on so called undesired behaviours which are seen as indices of poor animal welfare. Ethological data have been collected using the scan sampling method, so that the corresponding behaviours are given in percentages of the total observation time respectively in rates per hour. In contrast to the well investigated common ravens and keas, the study is one of the first in generating behavioural data of the great white pelican living in captivity.

The observations revealed a slight reduction of the keas pacing behaviours during the period of applying physical enrichment. While for the ravens and pelicans rarely respectively no undesired behaviours could be observed, other behaviours show significant alterations comparing the period without and with applying enrichment. For example, the ravens' frequency in displacing each other remarkably dropped after offering them the item.

In conclusion the obtained results provide a good data basis for monitoring bird behaviours in captivity. It was shown that physical enrichment can alter bird behaviour, however a larger sample size would be needed to draw firm conclusions. The current data could be used to make comparisons of bird behaviours across different zoos.

ZUSAMMENFASSUNG

Seit vielen Jahrhunderten hält der Mensch exotische Tiere in Gefangenschaft. Anfänglich rein zum Zwecke der Vergnügung und Unterhaltung änderte sich das Bewusstsein der Menschen im Laufe der Zeit und stellte das Tier als Subjekt der Forschung und Bildung in den Mittelpunkt zoologischer Gärten. Das erhaltene Wissen dient zur Optimierung der Haltungsbedingungen wodurch das Wohlergehen des Tieres in Gefangenschaft erhöht werden soll. Hierfür stellen die Verhaltensweisen des Tieres wichtige Indikatoren dar.

In dieser Arbeit wird untersucht inwieweit das Angebot eines Beschäftigungsobjekts eine Änderung der Verhaltensweisen von in Gefangenschaft lebenden Kolkraben, Keas und Rosapelikanen im Heidelberger Zoo hervorruft. Gleichzeitig wird ein Fokus auf sogenannte unerwünschte Verhaltensweisen gesetzt, welche als Indizien schlechten Wohlergehens dienen. Die ethologischen Daten werden über die Methode des Scan Samplings erhoben, sodass die entsprechenden Verhaltensweisen prozentual der beobachteten Zeit bzw. in Wiederholungen pro Stunde wiedergegeben werden. Im Vergleich zu den gut untersuchten Kolkraben und Keas, generiert die Studie erstmalige Daten über die Verhaltensverteilung von in Gefangenschaft lebenden Pelikanen.

Beobachtungen, welche im Zeitraum mit der Anwendung eines Beschäftigungsobjekts durchgeführt worden sind, zeigen einen verminderten Anteil des auf und ab Laufen innerhalb der Keas. Während bei den Kolkraben und Pelikanen kaum bzw. keine unerwünschten Verhalten beobachtet werden konnten, zeigen diese jedoch signifikante Änderungen anderer Verhaltensweisen zwischen den Phasen ohne und mit Beschäftigungsmöglichkeit.

Letztendlich stellen die Ergebnisse eine gute Datengrundlage der Überwachung der Verhaltensweisen von in Gefangenschaft lebenden Vögeln dar. Es wurde gezeigt, dass das Angebot eines Beschäftigungsobjekts die Verhaltensweisen eines Vogels verändern können. Allerdings ist eine weitaus größere Stichprobenanzahl vonnöten, um die aus dieser Studie gewonnen Erkenntnisse zu verifizieren. Mit den gewonnenen Daten können Vergleiche mit den Verhalten anderer Vögel unterschiedlicher Zoos angestellt werden.

1. INTRODUCTION

1.1. Keeping birds in captivity

The earliest notations of keeping wild birds in captivity go back to around 4500 years ago. In this time even the ancient Egyptians housed many different species such as falcons, peacocks or cranes. The first collections of exotic animals for study and amusement were kept by the Greeks. With *The History of Animals* the philosopher Aristotle was the first author of zoological documents (Hosey et al. 2011). Later, approximately 100 years BC, first breeding success with peacocks by Romans are documented. Along with returning from conquests exotic birds e.g. cranes, flamingos or pheasants were transported from northern Africa to Europe and were kept in private collections of wealthy Roman citizens. In Europe, keeping birds in captivity has been popular during the middle-age and many species of the Psitacciformes reached the continent. However, it is assumed, that in the 16th century, there was no or less knowledge e.g. food, care, illness about keeping these exotic birds in captivity, which led to a high rate of death (Wedel 2005). In order to keep these birds in captivity successfully, humans were forced to deal with the individual bird-species´ requirements. One of the first zoos dealing with husbandry conditions was: The Jardin des Plantes in Paris, which opened 1793 as one of the first scientifically conducted public zoos. Since 1804 Frédéric Cuvier was responsible for managing the livestock. His interests were primarily scientific behavioural research. By studying animal behaviour with focus on animal welfare, the chemist is seen as the first curator of a national zoo (Hosey et al. 2011). However, first major changes in zoo animal husbandry take place through the animal rights movement in the 1960s and 1970s. The public criticism on poor keeping conditions and the question whether zoos should exist, lead to a period of stagnation. During these times zoos were forced to rework their concept in animal husbandry and searched for new existential reasons (Hosey et al. 2011). Thus, even German politicians started in dealing with animal welfare in captivity and passed on October 1st 1972 the animal protection law. This act defines minimum standards in animal husbandry conditions. For each bird species the minimally housing conditions are defined in the second regulation of animal husbandry (Bundesministerium für Gesundheit 2007). On European level, the Directive 1999/22/EC on keeping wild animals in zoos additionally forces them to make a contribution to conservation. For maintaining an operating license, zoos have to take part in research activities from which conservation benefits accrue to the species (Council of the European Union 1999). This study investigates and compares the behaviours of three different bird species living in Zoo Heidelberg before and after enriching their aviary. Thus, the results of the measured behaviours of the birds can be seen as a research contribution of Zoo Heidelberg.

1.2. Animal behaviour

Human interest in animal behaviour goes back to prehistorical times, but systematic and scientific behavioural research started about 150 years ago. Although more than three million publications of animal behaviours have been published scientist still argue about a precise definition of animal behaviours (Kappeler 2012). Based on survey responses, Levitis and colleagues (2009) defined behaviour as “the internally coordinated response (actions or interactions) of whole living organisms (individuals or groups) to internal and/or external stimuli” (Levitis et al. 2009, p. 103). Thus animal behaviour can be seen as an adaption to its habitat, whereas the most important behaviours are: foraging, avoiding predators, finding sexual partners and breeding. These examples illustrate the necessity of tight collaboration of physiology, genetics, development and evolution to be able to perform the correct behaviour in each situation (Kappeler 2012). Furthermore, animal behaviour, as one part of an animal´s biology, is standing in a constant evolutionary process. So each species has developed its own behavioural repertoire, which can be seen as the product of the evolution. But in contrast to morphological or physiological attributes, behaviour is influenced by individual experiences and can change dramatically within the lifetime of an animal (Kappeler 2012; Hosey et al. 2011). For investigating an animal´s repertoire of behaviours, basic descriptive information, like compiling a catalogue (an ethogram), which contains all behavioural patterns of one species, is needed. In this study ethograms of three different bird species were generated. Since these animals are living in captivity, the extent of showing species-typical behaviour is influenced by several factors e.g. size of enclosure, number of conspecifics, visitors, food preparation and presentation etc. (Hosey et al. 2011).

1.3. Animal welfare

“Animal welfare science is the study of an animal´s quality of life” (Hosey et al. 2011, p. 219) and is determined by an animals physical and psychological condition. The difficulty in measuring animal welfare is to find objective indices describing an animals´ subjective state. One possible method for generating objective data is to measure the level of Glucocorticoids. By exposing an animal to a stressor its sympathetic nervous system induces an alarm response. This physiological process is mediated by hypothalamo-pituitary-adrenal (HPA) axis, which secrets adrenocorticotropic hormone (ACTH) and this in turn leads to the stimulation of the adrenal cortex to release glucocorticoids. Although the level of this stress hormone is a good parameter in assessing the physiological state of an animal, it does not necessarily indicate poor welfare (Hosey et al. 2011). With regard to the functions of Glucocorticoids (enhancing gluconeogenesis as well as the glycogen synthesis), a certain level of these hormones absolutely is essential for surviving (Berg et al. 2010). Furthermore, since the level of hormones depends on various factors e.g. time of day, pairing season etc., using this parameter for measuring animal welfare could lead to misinterpretations. However, these methods require intense and costly laboratory analyses, which cannot be conducted in this thesis. Another useful guideline for animal welfare assessment protocols are the five freedoms (Farm Animal Welfare Council 1993): freedom from hunger and thirst; freedom from discomfort; freedom from pain, injury and disease; freedom from fear and distress and freedom to express species-specific behaviour. These five freedoms have been criticized by Ohl and van der Staay (2012) in that the first four freedoms ensures welfare through the absence of negative states and only the last freedom includes that positive aspects assist in welfare. Thus it can be said that the more species-specific behaviours are performed by an animal in captivity the better its welfare. Therefore, for assessing animal welfare in this study there is a focus on some behavioural expressions listed in the observation protocols which are indices of poor animal welfare e.g. stereotypes like pacing (Mason and Latham 2004). Simultaneously these behavioural expressions are often classified as abnormal behaviours, which in turn are linked with compromised animal welfare.

Like the term ‘animal behaviour’, there is no consistent definition for ‘abnormal behaviours’. One common option to label a behaviour as ‘abnormal’ is to use a behavioural reference. Therefore, behaviours of animals living captivity will be compared with the correspond behaviours of their wild conspecifics and corresponding deviations will be declared as abnormal (Hosey et al. 2011). Mason (1991) showed that the term ‘abnormal behaviours’ can be used for describing a behaviour, that is (a) “rare or unusual” or (b) “apparently lacking in function and may be harmful to the animal, possibly as a consequence of some underlying pathology” (Hosey et al. 2011, p. 114). This study considers whether the three investigated bird species housed in Zoo Heidelberg perform behaviours which are classified as ‘abnormal’ respectively as ‘undesired’.

1.4. Environmental enrichment

Environmental enrichment can be defined as any change in a captive animal´s environment with the aim to improve the animal´s physical fitness and mental well-being (Beaver 1989; Hosey et al. 2011). That change can lead to the stimulation or prevention of specific behaviours which are linked to improved animal welfare like increasing activity and reducing stereotypes. A main aim of enrichment is to promote wild-type respectively normal behaviours in captive animals, which can be observed in wild conspecifics. However, promoting natural behaviours or preventing undesired behaviours is very difficult to achieve. In order to make valid comparisons between both kinds of behaviours data sets of both are necessary and especially the wild-type variant is very time-consuming, expensive and needs comprehensive knowledge of the wild animal´s behavioural repertoire (Hosey et al. 2011). Within this behavioural repertoire there are some characteristics which may influence the degree of success in using enrichment. Especially the characteristics neophobia and neophilia play a main role in its acceptance. Neophobia is the fear of anything new, whereas neophilia is the strong interesting in anything new. Thus a high level of neophobia could be an obstacle in taking contact which does not automatically mean that the enrichment item has no effect. In contrast a high level of neophilia could be beneficial for this study. There are no limits in the way how animals can get enriched. One of the most common enrichment methods is food based enrichment, which highly is accepted by the animals. Another method is physical enrichment. There, the animals receive an object for occupation. In contrast to food based enrichment, the animals are not motivated by external factor (e.g. hunger) in dealing with an physical object and they are free to deal with it (Hosey et al. 2011). In this study the birds receive a physical item for occupation.

1.5. Aims and hypotheses

The aim of this study is to measure the behaviours of common raven (*Corvus corax*), kea (*Nestor notabilis*) and great white pelican (*Pelecanus onocrotalus*) housed at Zoo Heidelberg before and after applying physical enrichment. Especially for pelicans, there is neither literature reporting on their behaviour in captivity nor exists any report about enriching a pelican-species. Therefore, species-specific ethograms and coding methods were generated, which also allow interspecies comparisons. In addition to the bird typical behaviours, a focus is set on abnormal (undesired) behaviours, which are indicators of poor welfare e.g. pacing or feather-plucking (Hosey et al. 2011). The behaviours focused on in the ethogram are based on pre-observations and literature. For example, in pre-observations it was already noticed that the young male kea living in Heidelberg Zoo is performing a stereotypical behaviour (jumps back and forth with a strong angulated head). One established method to reduce the rate of stereotypical behaviours is the application of different types of enrichment (Meehan et al. 2004).

Therefore, the aim of this study will be:

(1) to determine to which degree enrichment influences standard bird typical behaviours (e.g. feeding, resting, …) and

(2) to enhance natural behaviour expression, by increasing activity and preventing undesired behaviours (e.g. pacing, …).

In this context, based on literature and pre-observations, the following hypotheses are postulated:

(1) Because of the neophilic characteristics of kea (Keller 1975; von Dosky 2016) I hypothesize that they will show high rates of interactions with the new enrichment-item and reduced rates of undesired respectively stereotypical behaviours.

In pre-observations I observed that the ravens at Zoo Heidelberg are investing a lot of time to explore their aviary. But, in order to enrich them successfully, the ravens first have to overcome their neophobia (Heinrich 1988; Miller et al. 2015).

(2) For the ravens I therefore hypothesize that they will show a higher latency to contact and interact with the new enrichment item than the kea. But after establishing contact with the item, I hypothesize that the ravens will show significant alterations in their daily behaviour and a similar rate of interaction as the kea.

Notably, no literature could be found reporting on the behaviours of pelicans in captivity.

(3) Compared to the ravens and keas I hypothesize for the pelicans that they will show the least contact with the enrichment item. The behaviours before and after applying the enrichment item will be the same.

2. GENERAL INFORMATION ABOUT THE SPECIES

2.1. Taxonomy

In this study the behaviours of three different bird-species were investigated: *Corvus corax, Nestor notabilis* and *Pelecanus onocrotalus.* Through new molecular methods and genetic research, the classic morphological taxonomic system is constantly in revision. The bird-taxonomy also recently experienced some modifications. Alignments from nuclear loci as well as retroposom insertions (Suh et al. 2011) were made with regard to the phylogenetic position of Passeriformes (Wang et al. 2012; Hackett et al. 2008). The sister-relationship between Passeriformes and Psittaciformes (Fig. 1) has been genetically verified and bring *C. corax* and *N. notabilis* together. Therefore, the orders of both species can be grouped as *Psittacopasserae* (parrots and passerines) (Suh et al. 2011). Within the monophyletic group of Pelecaniformes, there are also some discords (Smith and DeSalle 2010). On one hand, the traditional taxonomy, based on comparative anatomy is setting *Pelecanus* in sister-relationship to other Pelecaniformes, such as *Fregata*, *Sula*, *Anhinga* or *Phalacrocorax* (Livezey and Zusi 2007). In this taxonomic system Pelecanifomes are clearly separated from Ciconiiformes (Fig. 2). On other hand, genetic analysis are separating *Pelecanus* from the rest of Pelecaniformes and is setting this order in direct relationship to other Ciconiiformes (Hackett et al. 2008). In the modern (molecular) system, *Scopus* and *Balaeniceps* are the sister groups of *P. onocrotalus*. In order to avoid confusion, in Tab.1 the standard classification after IUCN is given.

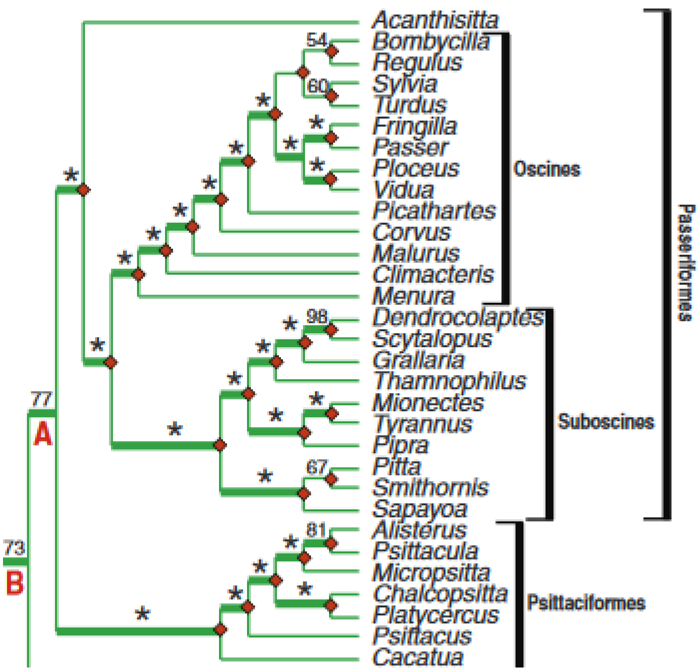


***Fig. 1**: Phylogenetic tree of Psittacopasserae. The excerpt from the phylogenetic tree is depicting the relationship between the Passeriformes and the Psittaciformes (Hackett et al. 2008)*

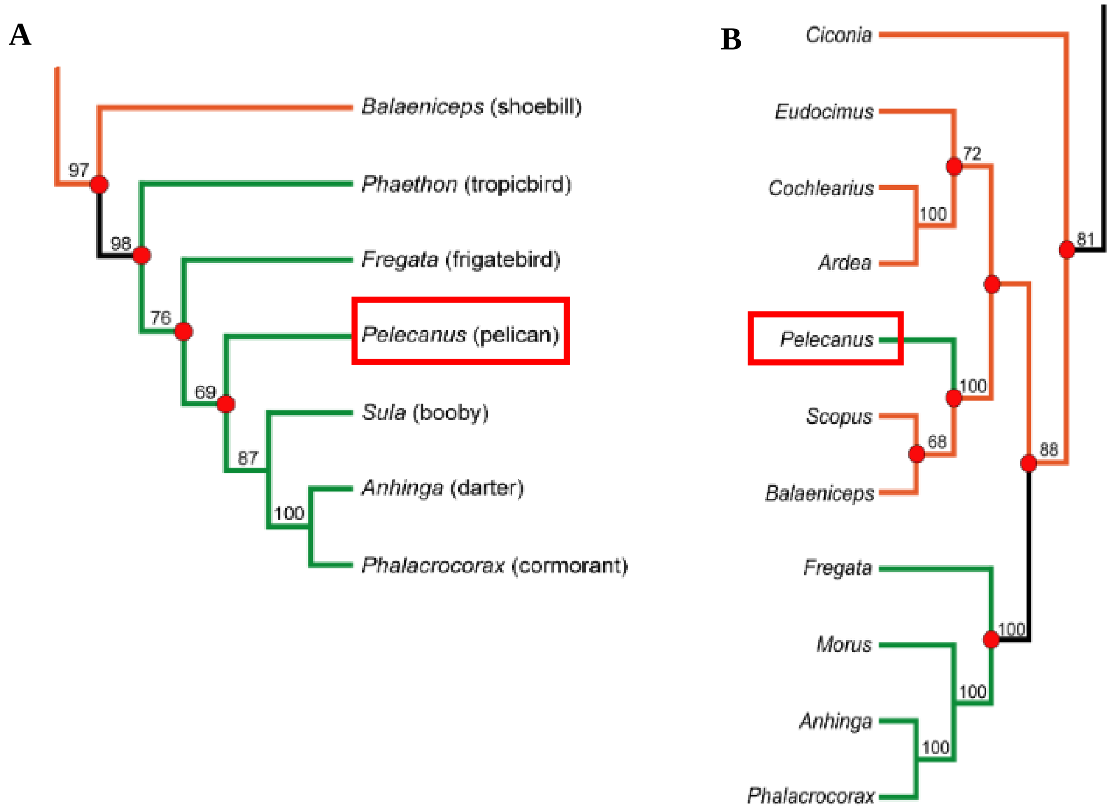


***Fig. 2**: (A) The phylogenetic tree is an excerpt from higher-order phylogeny of modern birds based on comparative anatomy (Livezey und Zusi 2007) showing the relationship of waterfowls based on comparative anatomy. (B) The excerpt from a phylogenomic Study of Birds Reveals Their Evolutionary History (Hackett et al. 2008) is depicting a part of phylogenetic tree based on molecular data. The colours of the branches represent classic avian orders: Cicooniiformes (orange), Pelecaniformes (green).*

***Tab. 1**: Taxonomy of the three investigated bird species at Zoo Heidelberg: Common raven (IUCN 2014), kea (IUCN 2012) and great white pelican (IUCN 2015).*

Kingdom	Animalia	Animalia	Animalia
Phylum	Chordata	Chordata	Chordata
Subphylum	Vertebrata	Vertebrata	Vertebrata
Class	Aves	Aves	Aves
Order	Passeriformes	Psittaciformes	Pelecaniformes
Family	Corvidae	Strigopidae	Pelecanidae
Genus	Corvus	Nestor	Pelecanus
Species	Corax	Notabilis	Onocrotalus
Scientific name	Corvus corax	Nestor notabilis	Pelecanus onocrotalus
Common name	Common raven	Kea	Great white pelican
Species authority	Linnaeus, 1758	Gould, 1856	Linnaeus, 1758

2.2. Characteristics of the investigated species

2.2.1. Corvus corax – Common raven

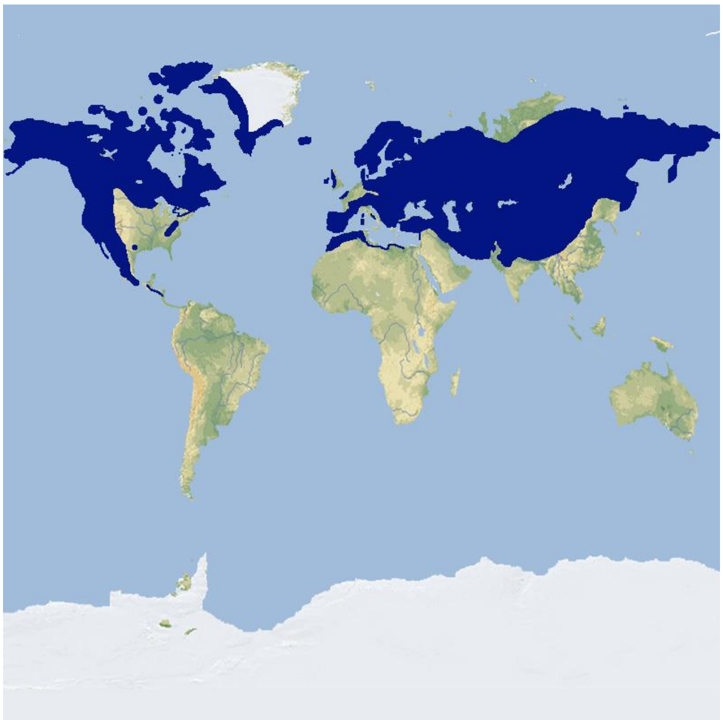
Identification

Degree of exposure: Least concern (IUCN, 2014)

With a body-length to 69 cm, a weight of 585 – 2000g and a wingspan up to 1,5m *C. corax* is the largest living passerines of the world. The bulky beak with nasal bristles, wedge-shaped tail-feathers and lanceolate throat feathers as well as the black metallic plumage are typical characteristics for common ravens (Koch et al. 1986). In the wilderness, a maximum life span of 20 years is reported (Wink and Ferdinand 2014), but in captivity ravens can reach up to 80 years (Hoyo et al. 2009).

Habitat and diet

This bird-species nearly occurs on the whole northern hemisphere (Fig. 3), settling in various biotopes such as artic areas, mountains, forests, deserts and even human cities. Having this high ecological potential, *C. corax* can be seen as an euryoecious species. Despite the high adaptability, "raven-free" areas had been existed in the middle of the 20th century as a consequence of human intervention (Koch et al. 1986). During this time, common raven wrongly had the reputation as vermin for agriculture and lower wild hunting and therefore was nearly eradicated by humans. After the Second World War the population has been recovered and since 2004 the IUCN declared *C.corax* worldwide with "Least concern" (IUCN Red List of Threatened Species 2015b). As an omnivore, this bird-species is accepting a high food supply, whereas the animalistic percentage of the diet predominates to ten times with respect to the herbal food (Koch et al. 1986). Especially rodents, sick and weak small animals (birds, mammalian, reptiles, fish), eggs from other bird-species as well as rotten carcass are essential parts of the diet (Stiehl and Trautwein 1991). But also invertebrates e.g. annelids or shellfish are accepted (Koch et al. 1986). New sort of food gets inspected with excessed caution and increased alert (Hoyo et al. 2009). Heinrich (1988) described an impressive behaviour of common raven before reaching a carcass for the first time. They perform sudden violent vertical leaps assisted by one or more wing beats (Heinrich 1988), so-called "jumping-jacks". This approaching manoeuvre may function in testing the presence of other scavengers, which could be a potential enemy for themselves. Furthermore *C. corax* perform a remarkable caching behaviour, which is influenced by presence and absence of conspecifics. Because of robbing the caches from each other, ravens try to escape from the sight of conspecifics during food caching (Heinrich und Pepper 1998).



***Pic. 1**: Habitat (blue) of Common raven (Corvus corax) on the northern Hemisphere (Hoyo et al. 2009).*

Reproductive and breeding behaviour

Like many other species within the genus *Corvus*, common raven has no sexual dimorphism. Normally, sexual maturity begins with two years and the first breeding again two years later (Koch et al. 1986). In the mating season once the monogamous *C. corax* has chosen its partner, life long bonds are formed. Both sexes are involved in nest-building, which are typically in 3 – 30 m height on trees, steep cliffs or artificial structures. After fertilization, the female generally lays four to six eggs, but up to eight are possible, and incubates them for 20 – 25 days. After hatching, the fledglings will remain with their parents for a few months, before abandoning the parental territory in late summer (Hoyo et al. 2009). They unite with other young sexually immature conspecifics to big swarms and remain in these aggregations as adults, if they are not able to occupy a territory (Braun et al. 2012). However, just seldom the squab leaves the place of birth for more than 100 km (Koch et al. 1986).

2.2.2. Nestor notabilis – Kea

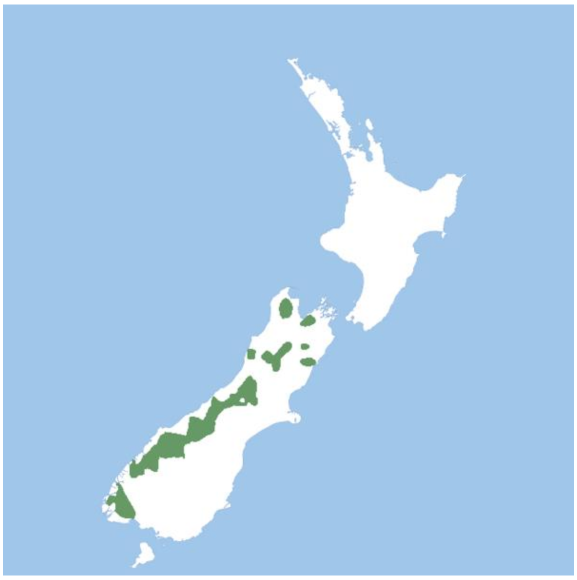
Identification

Degree of exposure: Vulnerable (IUCN, 2012)

A mean adult kea has a size of 48 cm and a weight of 922 g. The olive green metallic contour feathers with black edges, the scarlet underwings and its hook-shaped bill are unmistakable characteristics of kea. The head feathers, bill, ceres, iris, legs and feet are dark-brown. Tail feathers are short and squarely-shaped (Hoyo i Calduch, Josep del 2013). The oldest kea reported in wild was 20 years, the average life expectancy is 5 years (Heather and Robertson 1997). *N. notabilis* is one of the last two remained species of the unique genus *Nestor* within the *Strigopidae.*

Habitat & diet

The alpine-parrot is an endemic species of New Zealand, living in wooded valleys and subalpine scrublands at 600 to 2000 m of the south-west of the island. The ability of *N. notabilis* to occur in this kind of habitat is unique among Psitacciformes (Hoyo i Calduch, Josep del 2013). However, the contemporary population is estimated at 1000-5000 birds, which is just a fraction of what it once was. Like ravens, the kea had the reputation as a vermin of stockbreeding. Because of seeing kea as a sheep killer, the species extremely got persecuted up until its protection in 1970, over 150.000 birds were killed. Although high protection measures were passed, the current population trend after the IUCN is decreasing. The reason of the decline is the competition with various mammals such as cats and brush-tailed possums, which were introduced during European settlement. A further reason is the reduction of its habitat through deforestation for pasture (IUCN Red List 2015a). The diet of the kea is largely vegetarian (70.5%) (Brejaart 1988). Flowering mountain flax *(Phormium colensoi)*, rata *(Metrosideros)* and other trees and bushes were eaten during summer. In autumn the kea moves higher in the mountains to feed berries like Snow totara *(Podocarypus nivalis)* before descending below the timberline in winter (Hoyo i Calduch, Josep del 2013). Eating and dispersing more seeds than all other bird-species together, the kea is the most important seed disperser for the New Zealand´s alpine ecosystem (Young et al. 2012). The hook-shaped bill is ideal to dig for roots or to open hard-shelled fruits. The diet is complemented by flesh of carcasses and food from rubbish-dumps (Hoyo i Calduch, Josep del 2013).



Pic. 2: Distribution (green) of kea (Nestor notabilis) on New Zealand (KimvdLinde 2010).

Reproductive & breeding behaviour

The female with a less curved bill is approximately 10% smaller than the male. The polygynous breeding behaviour is uncharacteristic for parrots. One male kea can be attached to up to four females. Breeding behaviour can be observed the whole year with exception of late autumn. After fertilisation the female generally lays two to four eggs in a nest, which was built in crevice under rocks or in tree roots. Incubation time is about three to four weeks. The fledgling period is 13 weeks. Young female keas stay at their natal area, whereas the males tend to disperse. Because of polygyny only the dominant male keas breed in any given year (Hoyo 1997).

2.2.3. Pelecanus onocrotalus – Great white pelican

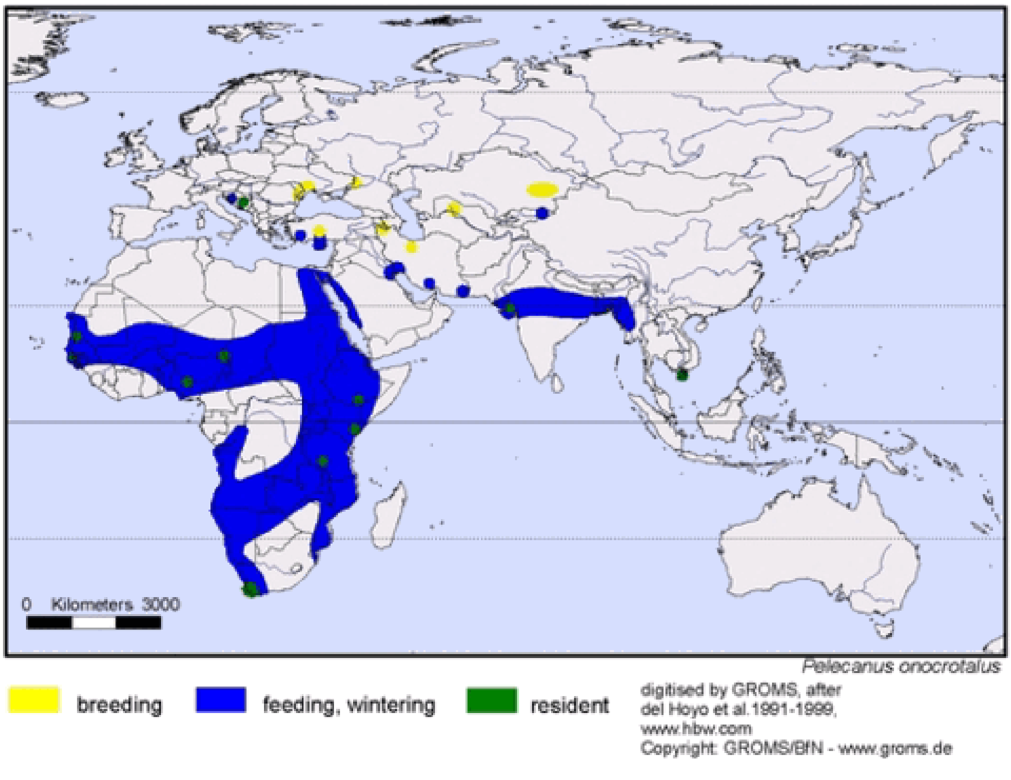
Identification

Degree of exposure: Least concern (IUCN 2015)

There are remarkable size differences between male and female pelicans. An adult male pelican has a mean length of 175 cm, a weight between 9 and 15 kg and the bill can reach up to 471 mm. The smaller female has a mean size of 148 cm, a weight between of 5,4 and 9 kg and a maximal bill length of 400 mm. The wingspan of both sexes varies from 226 to 360 cm. The flight-feathers are all black from below. The upper mandible is roughly scaled with intensively red coloured edges. The beak tip is nail shaped and red. The colour of the prominent throat pouch is pale yellow to ochre. In captivity pelicans regularly reach an age of 40 years, whereas in the wilderness the mean lifespan is estimated of 25 years (Hoyo 1992).

Habitat & Diet

The gregarious great white pelican predominately occurs from Southeast Europe through Asia and Africa (Catsadorakis et al. 2015; Hoyo 1992) (Fig. 5) and is the most widespread of Old World pelicans (Brown and Urban 1969). As a waterfowl, *P. onocrotalus* accepts brackish or fresh water of deltas, lakes or lagoons, but alkaline lakes are also accepted. In order to hunt fish successfully, shallow warm water is demanded (Hoyo 1992). The piscivorous great white pelican eats 450 - 2250 g fish per day. The amount of food depends on the weather conditions: the colder the more fish is needed (Brown and Urban 1969). In Europe especially *Cyprinus caripio*, in China *Mugit* and in India *Cyprinodon dispar* are preferred. In Africa the commonest preys are cichlids *Titapia* and *Haplochromis*. In order to optimize the fishing technique *P. onocrotalus* swims in flocks by following a leader performing formations like “following”, “nucleus” or “semicircle”. In some of these formations the bill-dipping rate gets synchronized, which increase the rate of prey (McMahon and Evans 1992). It is recorded that adult pelicans eats the chicks of other seabird species like Cape Cormorant (*Phalacrocorax capensis*). The predation on other seabirds even has taken the form of a predator prey relationship: Drop in cormorant numbers lead to a decline of the pelicans (Hoyo 1992).



***Pic. 3**: Distribution of great white pelican –Pelecanus onocrotalus (del Hoyo et al. 1991-1999).*

Reproductive & breeding behaviour

The beginning of breeding behaviour depends on the geographic occurrence. In Europe and India breeding starts in spring whereas in Africa breeding is possible the whole year (Hoyo 1992). The breeding colonies in Africa consist at least 2000 pairs of birds and are usually much larger. The largest recorded breeding colonies reached approximately up to 40.000 pairs at Lake Rukwa (Brown and Urban 1969). However, in contrast to other pelican species *P. onocrotalus* appears least threaten through human implications (Schreiber 1980). Owing of pesticide contamination like poisoning with polychlorinated biphenyls (DDT) populations of nearly all pelican species dramatically decreased (Crivelli and Schreiber 1984). Especially the Dalmatian pelican *P. crispus* and the grey pelican *P. philippensis* have been viewed in danger of extinction (Crawford et al. 1995), whereas *P. onocrotalus* population relatively stayed stable. Despite the worldwide decline of the remaining pelican species in this time, great white pelicans could raise in numbers on Dassen island of South Africa. Because there is no human disturbance and a high number of coastal water bodies, the 200-ha area provides good conditions for breeding and foraging (Crawford et al. 1995). The yellow areas in the map (Fig. 5) depict further breeding areas in Asia. The nest of the floor breeder consists of pile of reeds or sticks, sometimes it is built on a rock. It is presumed that great white pelican is monogamous and pairs just exist for one season. After fertilisation the female normally lays one to three eggs. Both sexes incubate them for 29 to 36 days. At the age of 65 to 75 days the chicks are fully-fledged. Sexual maturity generally develops at age of three to four years (Hoyo 1992).

3. MATERIALS & METHODS

3.1. Study Subjects and Housing

3.1.1. Common ravens

Male raven: Randall;

Date of birth: Between Dec. 2010 and Feb. 2011 in Department Ethology of University Bielefeld. Since Nov. 30th 2011 at Zoo Heidelberg (Zoo Heidelberg 2016a).

Female raven: Ivan;

Date of birth: Between Jan. 2008 and Jan. 2010. Comes from a private collection and since May 10th at Zoo Heidelberg (Zoo Heidelberg 2016b).

The flight aviary has a size of 3.5 x 7.1 x 2.7 m (24.9 m^2; 67.1 m^3) containing a roofed section in the background, which is not accessible for visitors. The closely-meshed fence is the same on all sites. The aviary is equipped with perches in different diameters, seat swings, tree stumps and sandy ground. Daily feeding takes place between 9am and 11am. In order to guarantee an optimized nutrition, the food varies daily. It contains fruits, vegetables, mice, rat babies, eggs, chicken’s chicks, mussels and sometimes hornbill-pellets or dog food. The female raven is hand-reared and was trained for the daily Zoo ‘Tiere-live show’. However, after the bird has flown away during a show, the training has stopped and the bird was taken out of the program. Mating with the male raven since November 2011. Till today neither nesting nor breeding success is documented.

3.1.2. Keas

Male kea: Crusty;

Date of birth: Apr. 27th 2013 in Zoo Heidelberg (Zoo Heidelberg 2016c).

Female kea: Maggie;

Date of birth: Jan. 15th 2014 in Vogelpark Marlow. Since Oct. 7th 2015 at Heidelberg Zoo (Zoo Heidelberg 2016d).

Both keas are kept in a 10 x 6 x 3 m (60 m^2; 180 m^3) flight aviary containing a standpipe, some trees, perches with different diameters and a platform which is hanged on ropes. The fence is rough meshed, whereas the back wall as well as the fence on the left are covered with wood panels. On the right side, there are dents in the wall for retreatment. The keas get fed twice per day: First feeding takes place in the morning around 9am and the second around 3pm. The food consists of nuts, fruits, vegetables, seeds and sometimes larvae. For successful breeding the Zoo Heidelberg replaced the male kea´s mother with the young female a couple of months ago. Till today no breeding success is documented.

3.1.3. Great white pelicans

The pelicans are neither named nor is the individual date of birth documented. Their age is estimated between 20 to 25 years. Sex, ring initials/ -colour and the bill length after documents of Zoo Heidelberg (Zoo Heidelberg 2016e) are given in Tab.2:

Tab. 2*: Great white pelicans at Heidelberg Zoo, 1.0: male; 0.1: female*

Sex	Ring initials, -colour	Bill-length [cm]
1.0	AZC, red	39
1.0	JJA, yellow	30
0.1	ZID, blue	31
0.1	ATR, red	30
0.1	JAF, green	29

The five great white pelicans are housed in an upwardly opened enclosure which directly is connected to the African enclosure. There the pelicans are socialized with Damara zebras (*Equus quagga burchelli)*, greater kudu *(Numida meleagris)*, blesbok (*Damaliscus pygrgus phillipsi)*, common ostrich *(Struthio camelus)* and helmeted guineafowl *(Numida meleagris)*. All five pelicans enjoy free-running on the whole area, but they always stay next to the standpipe of the enclosure. The size of the tank is 28 x 9 x 0,85 m (252 m^2; 214 m^3). As retreat opportunities from the other African animals, a platform and a tree stump are installed in the standpipe, which are only accessible for the pelicans. By pinioning the third and fourth metacarpal bones of one wing, the pelicans have lost their ability to fly and therefore can be kept in the upwardly opened enclosure. They get fed once per day at 2pm with common rudd (*Scardinius erythrophthalmus).* Till today no breeding success is documented, although the females lay eggs every year.

3.2. Physical enrichment

3.2.1. Enrichment-Item

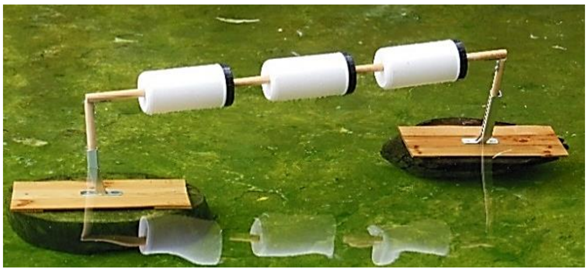
The item for enriching the aviary of ravens and keas was the same: “Motorikschleife”. With 28 x 18 x 27 cm the chosen size orientates to the size of the birds. The different conspicuous colours stimulate the bird’s optical system and should therefore gain their attention. For mechanically use the birds can use their beak intensively to slide the little logs of wood along the curved metallic sticks in many ways. In order to avoid an overturn, the object was fixed to a heavy slap (40 x 40 cm). By drilling two holes with a rock driller the item got screwed on the slap with two carriage bolts (Pic. 4).

Pic. 4*: Enrichment-item for raven and kea. The item got fixed on a slap.*

For the ravens the object got placed on the bottom in the centre of the aviary. For the keas it was placed on the bottom in the left backstage area of the aviary.

The aviary of the pelicans got enriched by a similar item which was created by myself (Pic. 5 and Pic. 6). Therefore, two broomsticks, two parts of a shelf, two metal rails, two angle brackets and three perforated (lid and base) tins (height: 25,5 cm; diameter: 13,2 cm) were used. The item had a height of 45 cm and a length of 1,3 m. In order to avoid contact from the other animals keeping on the African enclosure the item was fixed on two stumps (27 cm height; 62 cm total height) with bolts in the pelican´s standpipe. From the visitor´s point of view it was located on the right side of the standpipe. The tins stuck out of the water surface and were able to slide along the broomstick by the pelican´s beak.

Pic.5*: Enrichment-item for pelican.*



Pic.6*: Enrichment-item for pelican.*

3.2.2. Period of applying physical enrichment

Due to unexpected incidents it was not possible to enrich all three bird species within the same period of time and duration. Actually each bird species should be observed three weeks without and three weeks with enrichment, so that on each day two observation sessions per species could be made. The ravens got enriched from July 16th to August 6th 2016, the keas from July 17th to August 7th 2016 and the pelicans from July 28th to August 9th 2016. However, at least the hours (37,5 hours per species) of observation were the same for all three species. Reasons for delays in the schedule were: rainy days, construction works in the Zoo Heidelberg and personal illness.

3.3. Data collection

3.3.1. Ethogram

In order to measure the behaviours uniformly all three bird-species were observed with the same record methods and protocols. Therefore an ethogram was generated first based on preliminary observations, ethograms of other bird-species (Copsey 1995; Meehan et al. 2004) and with focus on behavioural indicators of poor welfare e.g. pacing, feather-plucking. The possible behaviours a bird could perform were defined, categorized and divided up into states (S) and events (E) (Naguib 2006). Abbreviations for the protocol of each category are in brackets. The pictures were taken with a digital camera (Nikon Coolpix S9200) and a smartphone (Samsung Galaxy A3). The ethogram for all three species are given in Tab. 3, 4 and 5.

3.3.2. Behavioural Observation Duration

In this behavioural study data of each of the three bird-species were collected for 37, 5 hours from the end of June 2016 to the beginning of August 2016. In order to investigate the influence of the enrichment item on the animals' behaviour two Datasets were generated: each with 18, 75 hours before and after applying the enrichment item. The records were distributed equally during the opening times of the Zoo Heidelberg (9am to 7pm). In total 112,5 hours (3 x 37,5h) of observation were made.

3.3.3. Behavioural Observation Protocol

The possible behaviours a bird can perform are separated into states and events. Behaviour patterns of relatively long duration like *inactive*, *locomotion* or *feeding* are regarded as states. Events are behaviour patterns of relatively short duration e.g. vocalisations (Altmann 1974; Martin and Bateson 2013). For recording the states of a group of animals the scan sampling method is used. To apply this method, the time of one observation session (45 min) is divided up into intervals of 30 seconds (time point sampling). Thus at each sampling point (each 30 seconds), a scan of the enclosure from left to right is made and the corresponding behaviours of each animal is noted in the protocol (Naguib 2006; Altmann 1974; Martin and Bateson 2013). For the relatively short events continuous recording is used. By counting these kinds of behaviours during the time of observation, this method allows to calculate the frequencies (e.g. rate per hour) of these short behaviours (Martin and Bateson 2013).

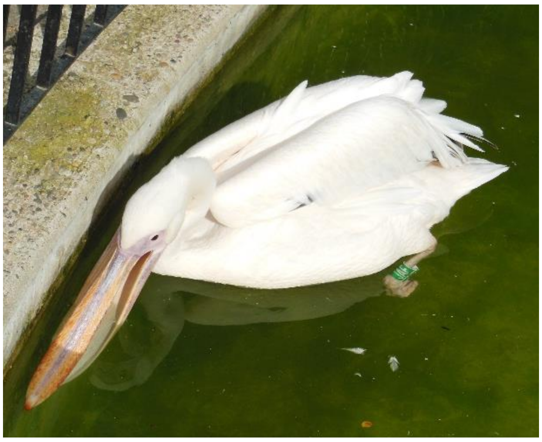
Solitary behaviours

The performance of the animal does not have any physical contact to a conspecific.

***Tab. 3**: Ethogram of the solitary behaviours of birds. S: State and E: Event.*

Behaviour	**Description**
Inactive (I), S	Sit: The animal is sitting on an advanced platform or on the ground, whereas the tarsi are bent. The digits are sprawled out. The animal is sitting on a branch, whereas the tarsi are bent. The digits encompass the branch.  ***Pic. 5**: Pelicans sitting on a stump.*
	Stand: The animal is standing either on an advance, bottom or on a branch. The tarsi are stretched out. Same for standing on one tarsus.
	Vapour: The animal stays still fluffing up its plumage.
	Wing-abducting: Sitting on the branch or bottom with abducted wings.
	Opened-beak: The animal is sitting or standing still with an open beak. No vocalisations are performed.
Locomotion (L), S	Walk: The animal is walking or jumping on the bottom or on a branch with or without wing beats.
	Fly: Through wing-beating, the animal is holding its body in the air for at least one second.

	Climb: The animal is climbing on the fence vertically or upside down.
	Swim: The animal is swimming on the water.
Alertness (A), S	The animal stands or sits with an upright body and an elongated neck. The head has to move abruptly in various direction.
Object-Exploration (O. Exp.), S	Nibble: The animal is gnawing or pecking on an object with its beak.  ***Pic. 6****: Kea is nibbling on enrichment-item.*
	Paw: The animal is scratching on an object with its feet.
	Lick: The animal is using its tongue to explore the object. Especially for the kea.
	Throw: The animal is throwing the object with its beak.
	Hold: The animal is holding an object by using its beak or feet.
	Transporting object: Holding the object with its beak, the animal is walking or flying in the aviary.
Foraging (Feed), S	The animal is chewing and feeding food.
	The animal is keeping the food in its claw or beak.
	The animal is drinking water from the standpipe.
	The animal is hackling food into palatable portions and feed it.

	The animal is dipping or holding its beak under water. Especially for pelican.  ***Pic. 7**: The pelican is holding its beak under water.*
Food-exploration (F. Exp.), S	Hide food: The animal is digging a hole in the ground with its beak or feet, put the food in it and burrows it.
	Transport food: The animal is walking, while keeping the food in its beak.
	Throw food: The animal is performing a fast head-turn to throw the food in a various way.
	Stick food on objects/fence: The animal is transporting the food to the fence or object, using its tongue to fix on it.
Self-directed (S. Direc.), S	Self-preening: Preening of the body by drawing the feathers through the beak. Scratching belongs to self-preening when it is performed together.  ***Pic. 8**: Pelican is preening itself.*

	Bathing: Being in the standpipe of the aviary the animal is dropping its wings on the water surface.  ***Pic. 9****: Kea is taking a bath.*
Flapping (Flap.), S	Standing on the ground the animal beats its wings up and down without raising up in the air. Especially for pelican.
Unexpected-behaviour (Ux. Bh.), S	The animal is performing a behaviour, which was not observed before and is not noted in this ethogram.
Scratching (Scrat.), E	The animal is scratching its head with its claws.
General-ruffle (G. ruffle), E	Shaking and ruffling of the plumage.
Vocalisation (VS), E	shouting, singing, tattling,
Yawning (Ywn), E	Opening the beak widely and stretching out the tongue.
Beak-peeling (B. peel), E	The animal is peeling it´s beak on a branch.

Social-Interaction

Social-interaction requires the presence of a conspecific. This category is divided up into positive social behaviour, antagonistic behaviour and social locomotion.

Tab. 4*: Ethogram of the social behaviours of birds. S: State and E: Event.*

Behaviour	**Description**
Social positive behaviour is performed with no violence or harm towards conspecifics.	
Social positive contact (Positiv), S	Contact: The animals are standing or sitting next to each other. Their bodies can touch. The space between them is less than 0.3m.  ***Pic. 10****: Ravens are standing next to each other.*
	Bill: The bills of both animals are in contact. Or one animal is tipping its bill against the bill of its conspecific.
	Social-Feed: One animal is feeding a conspecific. In order to transfer the pre-digested nutrition, bill contact is necessary.
Social-preening (S. Pre.), S	One animal is preening a conspecific with its beak. Usually the head of the conspecific will be preened.  ***Pic. 11****: Kea is preening it´s conspecific.*

Social-Locomotion (Soc. L), S	Affiliative-following: One animal is constantly following (walking, swimming) a conspecific for minimum five seconds and without having body contact.  ***Pic. 12**: Pelicans swimming as a flock.*
Approaching (Appr.), E	One animal is moving in the direction of a conspecific, which is standing still. The distance between the animals must be at least 1m before approaching started.
Sexual behaviour (Sex), E	The male is ascending the females´ back, while it is standing still. The cloaks are getting contact.
Agonistic contact describes violent as well as non-violent contacts between conspecifics. It involves conflict initiation and -avoiding.	
Agonistic contact (Ago.), S	Fight: Both animals are biting and grabbing each other. Usually fighting is accompanied by loud vocalisations.
	Hunt: The aggressor is rapidly following a conspecific, which is fleeing immediately. This action is often accompanied with wing beats.
	Exclaim against: One animal is screaming in the direction to a conspecific. The distance between the animal maximally is 0.5m. In order to note this behaviour, the screams minimally must have three repeats and short frequencies.
	Defencing: During an aggressive contact. The defender is standing still with an erectly and backwardly leaned body. Defencing is always accompanied with very loud vocalisations.
Displacing (Displ.), E	One animal is approaching to a conspecific, which is immediately avoiding contact and without any defence.

Undesired behaviour

The animal is performing a behaviour, which is uncommon in free-ranging animals. The behaviour patterns can be repetitive, invariant or appear with a lack of function (Hosey et al. 2011). The following behaviours were used to describe occurrences of poor animal welfare. The behaviours pacing, feather-plucking and perch-dancing come from literature, whereas the behaviours beak-pull and standing in corner come from pre-observations of the keas.

Tab. 5*: Ethogram of the undesired behaviours of birds. S: State and E: Event.*

Behaviour	**Description**
Pacing (Pac), S	The animal is walking back and forth. In order to note this behaviour, the performance must take minimally five seconds and two returns. Mostly the animal walks along a fence.
Feather-Plucking (F. P.), S	The animal is picking its feathers out of its body. The plumage is showing open areas.
Beak-pulling (B. Pull), S	The animal is pulling on its lower mandible with its foot for minimally five seconds.
Standing in corner (S.i.c), S	The animal is leaning in one corner of the aviary for minimally five seconds. The head is in the corners direction.
Perch-dancing (P. dac.), S	The animal is standing on a branch, leaning its body alternately and repetitively from the left to the right.

Not visible

Not visible (N.V.)	The behaviour of the animal is not visible to the observer (the animal may be visible but obscured in some way so that the data collector cannot tell what it is doing).

3.4. Data processing

For statistical analysis the states (solitary, social, undesired behaviours) are represented in diagrams, which depict the behaviours of each species in percentage of the time of observation. Therefore, the states of each behavioural category per observation session were counted and listed in an Excel worksheet. These data sets were complemented by date, recording time, temperature and weather conditions. For generating percentages of each behavioural category, the mean value (M) as well as the standard error (SE) were calculated and set in formulas given in the following:

$$\text{Percentage of time of behaviour (M\%)} = \frac{M}{Number\ of\ scans\ x\ number\ of\ animals}\ x\ 100$$

$$\text{Standard error (SE) of states} = \frac{Standarddeviation\ (M\%)}{\sqrt{Number\ of\ observations}}$$

In the case of the events (E), the behavioural protocols were used to calculate the frequency of each behaviour per hour and per animal. The results will be represented in tables.

$$\text{Frequency (F) of events} = \frac{M\ x\ 60\ [min]}{time\ of\ observation\ [min]\ x\ number\ of\ animals}$$

$$\text{Standard error of frequency of events} = \frac{SE\ (F)\ x\ 60\ [min]}{time\ of\ observation\ [min]\ x\ number\ of\ animals}$$

3.5. Methods of data analysis

For data analysis descriptive as well as inductive statistics was used. In the descriptive part diagrams and tables were generated with Microsoft Office Excel 2016. The behavioural states are represented in bar charts, whereas the events are given in tables. Before using inductive statistics in Statistica 13 (©2016 StatSoft Statistica) first, the data got checked for normal distribution by Shapiro-Wilk test. This test shows that most of the data are not normal distributed ($p < 0.05$). On the basis on these results and because of the little number of investigated animals per species, non-parametric tests were used. In order to find out significant differences within the bird´s behaviours before and after applying physical enrichment the Wilcoxon test was used.

4. RESULTS

The results of the descriptive as well as the inductive statistics are presented below. A complete list of all results is given in the Appendix. There the corresponding mean-values, Standard deviations and Standard errors and p-values of each statistical test can be consulted.

4.1 Descriptive Statistics

4.1.1. Latencies

For measuring the latency of each bird species the day of the first contact with the item was noted. There was no distinction between the individual animals. For the keas, first contact was recorded on the first day of applying the item, for ravens and pelicans no contact could be observed.

4.1.2. Descriptive Statistics of states

To illustrate in which degree physical enrichment influences the behaviours of raven, kea and pelican in captivity comparative bar charts were generated. The diagrams depict the behavioural states before and after applying enrichment in percentage of the total observation time.

Description of the solitary behaviours of the states:

Ravens (A)

As shown in Figure 3A the ravens were most of the observation time *inactive* (M_{wo}[1] = 30.49; SE_{wo} = 3.22) without as well as with enrichment (M_w[2] = 29.16; SE_w = 3.48). Being *alert* was the second most performed behaviour (M_{wo} = 19.07; SE_{wo} = 2.29) of ravens and rarely changed with enrichment (M_w = 18.56, SE_w = 2.58). 16.51% of observation time the birds spent in the movable behaviour *locomotion* within the aviary and increased slightly by 1.11% with enrichment. The fourth most common behavioural state was *feeding* which stayed constant at M_{wo} = 13.44 respectively at M_w = 13.14. However, the time of performing *food exploration* slightly dropped during the enrichment period from M_{wo} = 4.76 to M_w = 3.64. The percentage of self-directed behaviour increased a little from M_{wo} = 8.93 to M_w = 9.78. Despite of offering an item for occupation there was no remarkable difference within the category *object exploration* M_{wo} = 2.11 respectively M_w = 1.87. About 2% (M_{wo} = 2.09%; M_w = 2.04%) of the raven's behavioural states could not be defined clearly and were noted as *unexpected behaviour*.

Keas (B)

The three most performed behavioural states of keas before enriching their aviary were: *Inactive* (M_{wo} = 20.24, SE_{wo} = 3.92), *locomotion* (M_{wo} = 19.36; SE_{wo} = 2.25) and *feeding* (M_{wo} = 19.31; SE_{wo} = 4.58) (see Fig. 3B). The percentage of these three states changed after offering the "Motorikschleife", so that *inactive* increased about 7.96% (M_w = 28.20; SE_w = 4.39),

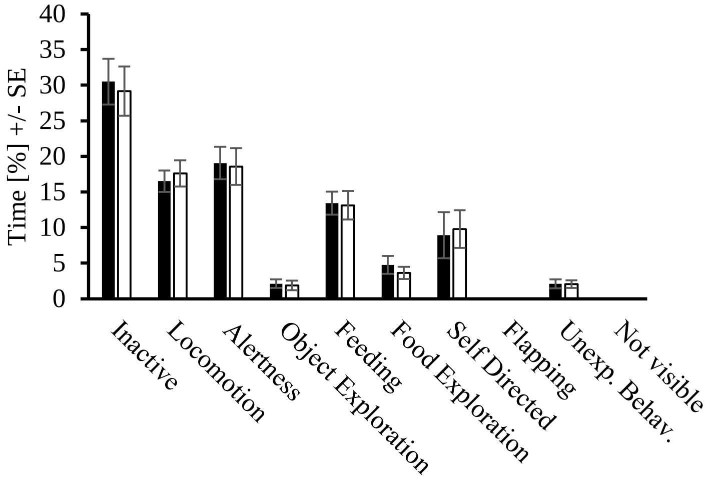
[1] M_{wo} Mean-value without enrichment
[2] M_w: Mean-value with enrichment

locomotion dropped by 4.52% (M_w = 14.84; SE_w = 1.55) and the eating behaviour raised by 3.8% (M_w = 23.11; SE_w = 4.00). There is no noticeable change (0.47%) in the kea´s *alertness* during the period with enrichment. Despite of offering an enrichment-item for occupation the kea´s behaviours in *object exploration* remarkable decreased from M_{wo} = 8.07 to M_w = 4.20. The *exploration* with *food* stayed constant and was performed very less by ca. 0.5%. With the application of enrichment there is an increase of 2.86% within *self-directed* behaviours. Only M_{wo} = 0.27 respectively M_w = 0.22 per cent of the observed time, the behaviours of the kea could not relate clearly and was noted as *unexpected*. With a decrease of 3.55% the keas were less *not visible* in the period with enrichment than without.

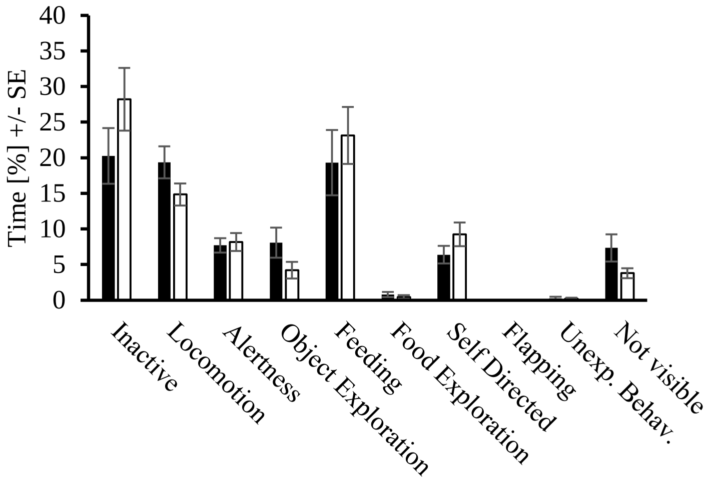
Pelicans (C)

Figure 3C shows that the most common behaviour before as well as after applying enrichment of the pelicans is *self-directed.* During the enrichment phase it rose from M_{wo} = 33.88 to M_w = 37.35. There is also an increase by 4.44% after offering the enrichment item in being *inactive*, which is the second most common behavioural state of the pelicans. The movable *locomotion* showed a decline in the period of enrichment and falls from M_{wo} = 17.48 to M_w = 15.26. Being *alert* was less performed (M_{wo} = 4.71; SE_{wo} = 1.20) and little dropped with enrichment (M_w = 3.46; SE_w = 1.01). The eating behaviours relatively stayed constant at ca. 2% of observation time, whereas *food exploration* was performed very less (M_{wo} = 0.11 respectively M_w = 0.43) before and after applying enrichment. The same can be considered for *object exploration* which increased about 0.46% to M_w = 0.53. The percentage of *flapping* behaviour virtually halved from M_{wo} = 1.13 to M_w = 0.67. Only 0.22% before respectively 0.04% after offering enrichment of the behaviours could not be classified and were noted as *unexpected behaviours.*

A: Solitary behaviours raven, N = 2



B: Solitary behaviours kea, N = 2



C: Solitary behaviours pelican, N = 5

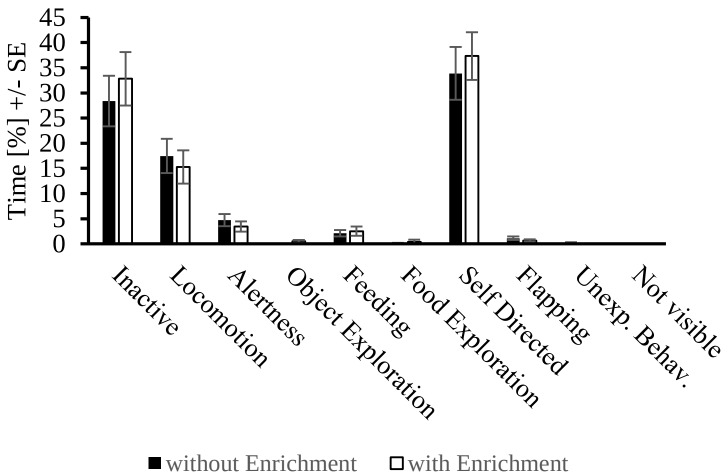


***Fig. 3**: The bar charts are depicting the solitary behaviours of the states in percentages of the total observation time before and after applying physical enrichment. The behaviours are represented by mean value (M) and Standard error (SE). (A) is depicting the percentages of time spending in the behaviours of Common raven, (B) kea and (C) pelican.*

Description of the social behaviours of the states:

Ravens (A)

As social behaviours ravens only performed the categories *positive* and *agonistic* (see Fig. 4A). *Positive* behaviours rose from M_{wo} = 1.29 to M_w = 3.27 (1.98%) after enrichment and *agonistic* behaviour little decreased from M_{wo} = 1.13 to M_w = 0.91 (0.22%).

Keas (B)

Within the social behaviours keas performed *positive* behaviour most (M_{wo} = 2.38; SE_{wo} = 0.67), which is showing a weak drop (0.47%) with enrichment (M_w = 1.91; SE_w = 0.54). The other social behaviours *social preening* and *agonistic* were performed very less (>1%) and showed virtually no difference after offering enrichment. *Social locomotion* only was observed within the phase of enrichment (M_w = 0.29; SE_w = 0.29).

Pelicans (C)

The social behaviours *positive* (M_{wo} = 0.80; SE_{wo} = 0.58) and *agonistic* (M_{wo} = 0.48; SE_{wo} = 0.29) were performed very little, whereas *positive* behaviours decreased more (0.76%) than *agonistic* behaviours (0.34%). *Social locomotion* falls from M_{wo} = 10.78 to M_w = 6.76.

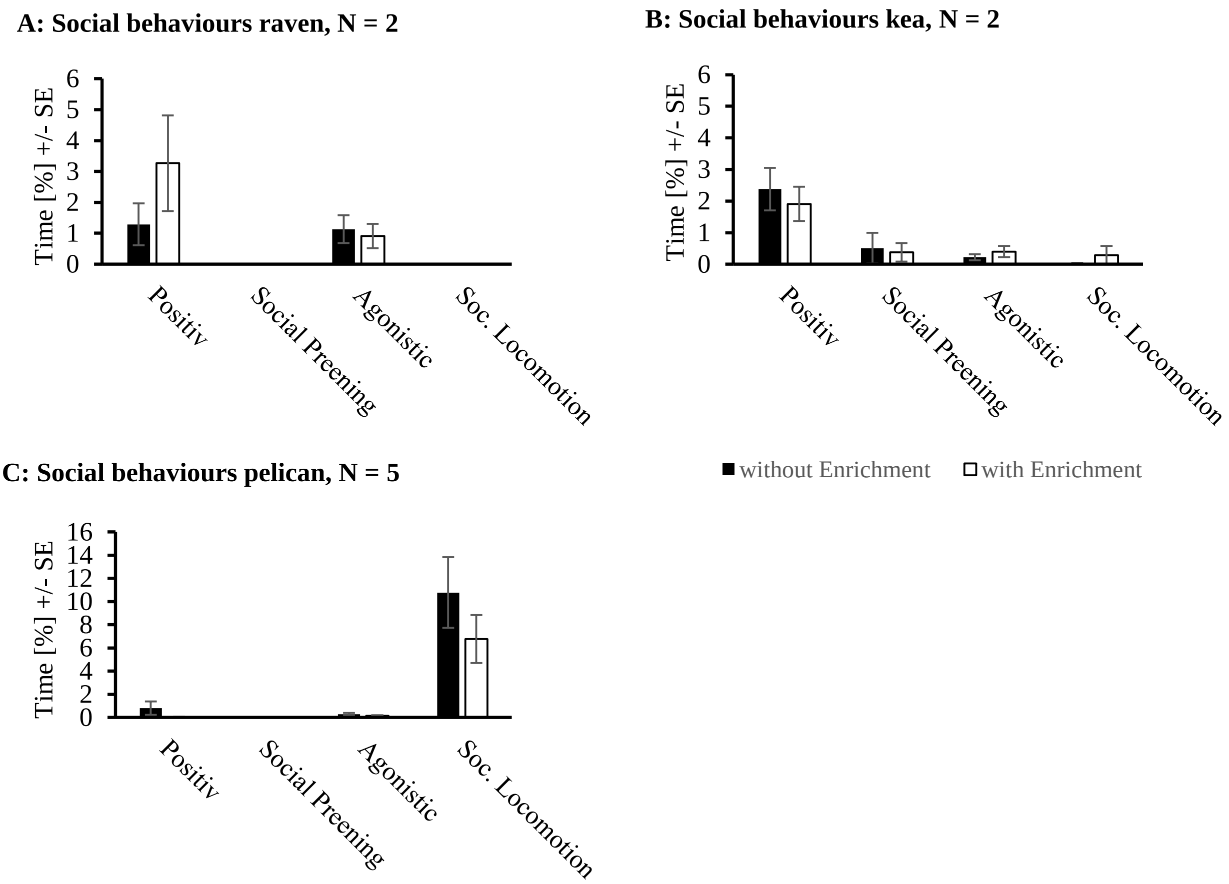


Fig. 4*: The bar charts are depicting the social behaviours of the states in percentages of the total observation time before and after applying physical enrichment. The behaviours are represented by mean value (M) and Standard error (SE). (A) is depicting the percentages of time spending in the behaviours of Common raven, (B) kea and (C) pelican.*

Description of the undesired behaviours:

In this study undesired behaviours are seen as indicators of poor animal welfare. The variables: Feather-plucking and perch-dancing were not performed by any species and were excluded in the diagrams. Since the pelicans did not perform any of the as undesired defined behaviours, no diagram for them is generated. S.i.c. is the abbreviation of the behaviour: *Standing in corner*

Ravens (A)

The only undesired behaviour ravens performed was *standing in corner* (S.i.c.) which was very little performed before (M_{wo} = 0.18; M_{w} = 0.06) as well as after offering physical enrichment M_{w} = 0.02; SE_{w} = 0.02) (see Fig. 5A).

Keas (B)

Considering the undesired behaviours of the keas, the percentage of *pacing* decreased about 2.36% from M_{wo} = 6.87 to M_{w} = 4.51 after applying the enrichment item (see Fig. 5B). The other two undesired behaviours *Beak pull* (M_{wo} = 0.40; SE_{wo} = 0.14) and *Standing in corner* (M_{wo} = 0.18; SE_{wo} = 0.11) are very less performed but both show a little drop within the period of enrichment (*Beak pull*, M_{w} = 0.20; SE_{w} = 0.10) respectively (*S.i.c.*, M_{w} = 0.11; SE_{w} = 0.07).

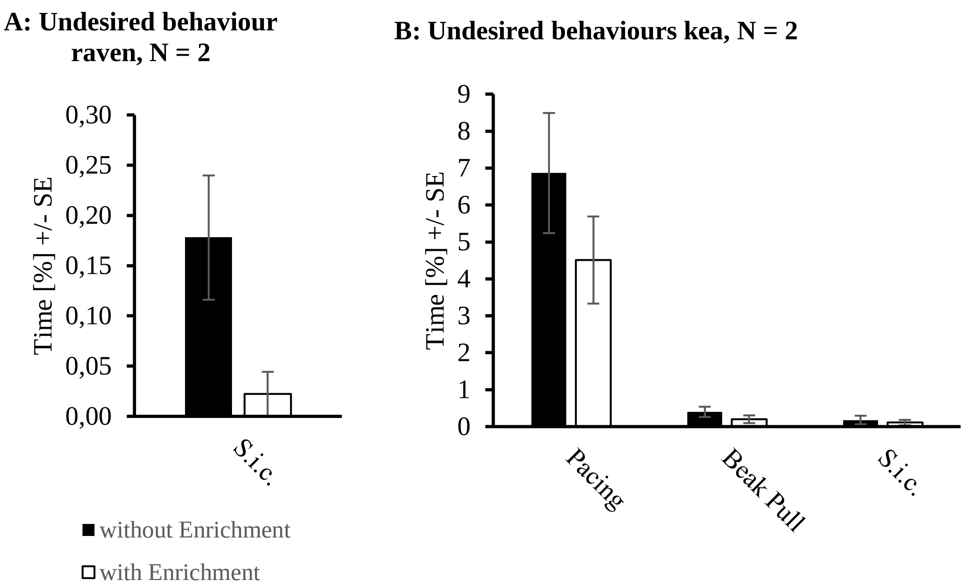


***Fig. 5**: The bar charts are depicting the undesired behaviours of the states in percentages of the total observation time before and after applying physical enrichment The behaviours are represented by mean value (M) and Standard error (SE). (A) is depicting the percentages of time spending in the behaviours of Common raven and (B) kea.*

4.1.3. Descriptive Statistics of events

The tables (Tab. 6 and 7) depict the behavioural events before and after applying enrichment in frequencies [1/h]. Tab.6 represents the solitary events, whereas the social events are given in Tab.7.

Description of the solitary behaviours of the events:

Ravens (R)

As the results in tab. 6 show, the ravens most common performed solitary event was *vocalisation*. This event decreased a little during enrichment from 58.05 to 55.04 vocalisations per hour. The second most common event is *Beak-peel*, which also shows a fall from 6.83/h to 5.84/h. The ravens made 3.55 *general ruffles* per hour without and 2.96/h with enrichment. *Scratching* is the only solitary event showing an increase during the time of enrichment and raised by 0.27 up to 1.07 scratches per hour. *Yawning* was the least observed behavioural event and dropped in the enrichment phase down to 0.03 *yawns* per hour.

Keas (K)

Like the ravens the most common performed event of the keas are *vocalisations*. In the phase of enrichment, the keas rate of *vocalisations* improved about 1.87 up to 23.31 per hour. The second most common performed event is *general ruffle* which slightly decreased by 0.13 ruffles per hour within the period of enrichment. The keas *yawned* without enrichment 0.85/h and with 0.43 times per hour. However, *scratching* showed an increase and raised from 0.61 to 0.83 *scratches* per hour. *Beak-peel* is the least performed solitary event of the keas and even dropped from 0.48 to 0.40 *beak-peels* per hour.

Pelicans (P)

Concerning the events of the pelicans in tab.6, *general ruffle* was the most performed solitary event before (F_{wo}[3] = 1.40 ± 0.24) and after (F_w[4] = 1.07 ± 0.21) applying physical enrichment. Compared to the other two investigated bird-species, their frequency of *vocalisations* is very little (F_{wo} = 1.19 ± 0.30) and even dropped about 0.66 *vocalisations* per hour with enrichment (F_w = 0.53 ± 0.10). On average a pelican *yawned* 0.66 times per hour without enrichment and with 0.32 times per hour. The *scratching* behaviour remained stable between 0.22/h without respectively 0.21/h with enrichment.

[3] F_{wo}: Frequency without enrichment
[4] F_w: Frequency with enrichment

__Tab. 6__: Results of the solitary events. The behaviours are given in frequencies per hour. R: Raven, K: Kea, P: Pelican. Without: without enrichment; with: with enrichment

Behaviours	**Species**	**Frequency [1/h] (mean ± SE)**	
		without	**with**
Scratch	R	0,80 ± 0,14	1,07 ± 0,38
	K	0,61 ± 0,14	0,83 ± 0,21
	P	0,22 ± 0,05	0,21 ± 0,06
General ruffle	R	3,55 ± 1,06	2,96 ± 0,68
	K	1,17 ± 0,33	1,04 ± 0,24
	P	1,40 ± 0,24	1,07 ± 0,21
Vocalisation	R	58,05 ± 8,15	55,04 ± 9,51
	K	21,44 ± 5,90	23,31 ± 5,64
	P	1,19 ± 0,30	0,53 ± 0,10
Yawn	R	0,35 ± 0,12	0,03 ± 0,03
	K	0,85 ± 0,66	0,43 ± 0,17
	P	0,66 ± 0,12	0,32 ± 0,08
Beek Peel	R	6,83 ± 0,93	5,84 ± 0,64
	K	0,48 ± 0,23	0,40 ± 0,12
	P		

Description of the social behaviours of the events:

In the study sexual behaviour could not be observed neither in the period without nor with enrichment.

Ravens (R)

During the period of enrichment, the ravens' rate of *approach* increased from 0.43/h to 0.91/h. In contrast, the rate of the antagonistic event *displace* remarkably dropped from 3.28 to 2.00 *displacements* per hour (see tab.7).

Keas (K)

Considering the positive social event *approach*, there is a decrease of 0.35/h between both observation periods. Without enrichment the rate of *approach* was by 1.79 per hour, whereas with enrichment the keas approached with a frequency of 1.44. Their behaviour in *displacing* remained constant before (F_{ow} = 2.61 ± 0.51) and after (F_w = 2.59 ± 0.46) offering physical enrichment.

Pelicans (P)

The pelican's social events both showed a fall after using enrichment. Without enrichment they *approached* 0.47 times per hour and with enrichment 0.28 times per hour. The same for displace: After installing the item in their enclosure it dropped from 0.23/h to 0.13/h.

Tab. 7: Results of the social events. The behaviours are given in frequencies per hour. R: Raven, K: Kea, P: Pelican. Without: without enrichment; with: with enrichment.

Behaviours	Species	Frequency [1/h] (mean ± SE) without	Frequency [1/h] (mean ± SE) with
Approach	R	0,43 ± 0,15	0,91 ± 0,35
	K	1,79 ± 0,29	1,44 ± 0,26
	P	0,47 ± 0,24	0,28 ± 0,08
Sex	R		
	K		
	P		
Displace	R	3,28 ± 0,53	2,00 ± 0,33
	K	2,61 ± 0,51	2,59 ± 0,46
	P	0,23 ± 0,07	0,13 ± 0,05

4.2. Inductive statistics

Because of the low numbers of animals per species and very little normal distributions (see Shapiro-Wilk values in Appendix) the non-parametric Wilcoxon test was applied in Statistica 13 for comparing the behaviours statistically before and after enriching the aviary/enclosure of the three bird species.

4.2.1. Inductive statistics of states

Description of the inductive statistics of the states

The results of the Wilcoxon test show that there are only a few significant differences in comparing the behavioural states without and with enrichment (see Tab. 8). Within the ravens there is only one significant reduction in *Standing in corner (S.i.c.)*. Pelicans showed a significant reduction in *unexpected* and *positive* behaviours during the period of enrichment, whereas *object exploration* shows a light trend in increasing. With a p-value of 0.185 there is a slight trend in reducing *beak-pull* within the keas.

***Tab. 8**: The table contains the statistical values of the non-parametric Wilcoxon test of the states. The test was done with each behaviour pattern without and with enrichment. Z: Z-value and p-value (>0.05) of Wilcoxon-test. Significands are coloured in red.*

Behaviours	Wilcoxon test: Ravens Z	Ravens p	Keas Z	Keas p	Pelicans Z	Pelicans p
Solitary						
Inactive	0,067	0,946	1,238	0,216	0,632	0,527
Locomotion	0,605	0,545	1,211	0,226	0,673	0,501
Alertness	0,390	0,696	0,086	0,932	0,763	0,445
Object Exploration	0,578	0,563	0,955	0,339	1,503	0,133
Feeding	0,296	0,767	0,673	0,501	0,317	0,751
Food Exploration	0,259	0,796	0,628	0,530	0,447	0,654
Self-Directed	0,586	0,558	1,080	0,280	0,431	0,667
Flapping					1,536	0,125
Unexp. Behav.	0,539	0,590	0,210	0,834	2,251	0,024

	Ravens		Keas		Pelicans	
Social	**Z**	**p**	**Z**	**p**	**Z**	**p**
Positive	0,711	0,477	0,523	0,601	2,24	0,025
Social Preening			0,524	0,600	1,342	0,180
Agonistic	0,471	0,638	0,711	0,477	0,937	0,349
Soc. Locomotion			0,447	0,655	0,657	0,511
Undesired	**Z**	**p**	**Z**	**p**	**Z**	**p**
Pacing			1,008	0,313		
Feather Pluck						
Beak Pull			1,325	0,185		
Standing in corner	1,960	0,049	0,338	0,735		
Perch dance						
Not visible			1,429	0,153		

4.2.2. Inductive statistics of events

Description of the inductive statistics of events

Like the states the outcome of the Wilcoxon test only depicts a few significant differences in the events without and with enrichment. Remarkably the rate of the event *yawn* significantly decreased in ravens ($p = 0.012$) as well as in pelicans ($p = 0.019$). The raven further significantly reduced their rate in *displacements* ($p = 0.049$) due enrichment. With a p-value of 0.052 the pelicans show a strong trend in reducing their rate of vocalisations after installing the item in their enclosure. Keas do not show any significant change in the events as in their states.

***Tab. 9**: The table contains the statistical values of the non-parametric Wilcoxon test of the events. The test was done with each behaviour pattern without and with enrichment. Z: Z-value and p-value (>0.05) of Wilcoxon-test. Significands are coloured in red.*

Behaviours	Wilcoxon test					
	Ravens		**Keas**		**Pelicans**	
Solitary	**Z**	**p**	**Z**	**p**	**Z**	**p**
Scratch	0,142	0,887	0,915	0,360	0,08	0,936
General ruffle	0,350	0,727	0,022	0,983	0,942	0,346
Vocalisation	0,471	0,638	0,500	0,617	1,946	0,052
Yawn	2,520	0,012	0,384	0,701	2,352	0,019
Beek Peel	1,130	0,258	0,345	0,730		
Social	**Z**	**p**	**Z**	**p**	**Z**	**p**
Approach	0,812	0,414	1,251	0,211	0,131	0,896
Sex						
Displace	0,196	0,049	0,438	0,661	0,876	0,381

5. DISCUSSION

5.1. Discussion of the results

Before interpreting any of the results it has to be made clear, that no external validity can be achieved from a sample size of two respectively five birds per species. Thus, the discussion of the results only focuses on the behaviours of the birds housed in Zoo Heidelberg. This assumption is valid for the following discussion parts.

The presented study was conducted to investigate to what extent enrichment influences the behaviours of common ravens, keas and great white pelicans living in captivity. In addition, a special focus was set on so called undesired behaviours which are seen as an indicator of poor animal welfare.

Considering the descriptive as well as the inductive results there are a few significant differences, but not within the hypothesized behaviour categories (see Introduction) -except *Standing in corner* of the ravens. I will discuss in how far the postulated hypotheses apply to the birds housed in Zoo Heidelberg in chapter 5.2.

Analysis of the results of the solitary behaviours: Inactive, feeding and flapping

As the descriptive results show in 4.1., the solitary behaviours (states) within each bird species show great similarity before and after offering physical enrichment. All three bird species spent much of their time being *inactive*. One aim in this study was to increase the level of activity (by decreasing inactivity) of the animals by offering them an enrichment item for occupation. Nevertheless, keas and pelicans showed an increased level of *inactivity* (kea: +7.96%; pelican: +4.44%) during the period of enrichment. For the keas this could be explained by the lower percentage of *not* being *visible* (-3.55%) with the enrichment, which led to a shift in the distribution of the behavioural categories and in turn justifies the enhanced level of inactivity. In general, a high percentage of this behaviour can be seen as a consequence of living in captivity. Since the basic physiological needs (hunger and thirst) are automatically satisfied by the zoo-management, the animals do not have to invest time and energy in finding food (e.g. hunting) or water which could explain these high percentages of being *inactive*. But a high level of inactivity has to be differentiated with apathy, which in turn is an indicator for diseases (Wink and Ferdinand 2014). Also the behaviour pattern *feeding* is regulated by the Zoo management. Feeding behaviour absolutely depends on feeding times of the zoo keepers. Concerning the results of this state, all three species showed relatively constant percentages in *feeding* behaviour without and with enrichment. The keepers have probably followed their feeding times strictly during my observation time, since all observations were made pseudorandomly distributed to reflect the whole the day (9am until 7pm). In contrast to the ravens and keas, the amount of food for pelicans depend on how much they can eat within their feeding time at 2pm. This punctual feeding method led to the rarely observed *feeding* behaviour in pelicans. This explains the low percentage of *feeding* for pelicans ($M_{ow} = 2.12\%$; $M_w = 2.52\%$). Interestingly, after the pelicans got fed with fish, they started holding their opened beak under water for several minutes. This behaviour has also been described in McMahon and Evans (1992) as a strategy of hunting. It appears that the taste or smell of fish triggers this behavioural pattern. Ravens and keas received their food in a bowl which was left there until the next feeding time. Thus, their *feeding* behaviour could spread over the whole day. Although both species got fed by the same method and received their food in the morning, the keas spent (5.87% without enrichment, 9.97% with enrichment) more time *feeding* than the ravens. Because of the high *feeding* behaviour, it seems that keas have a faster metabolism than ravens and therefore need more food for satisfying their demand for energy. When looking at *flapping* behaviour, the results show that only the pelicans performed it before as well as after applying enrichment. Comparing the wings between pelicans, ravens and keas, only the pelicans have been cropped on one wing. Due to the lack of flight, their wings may suffer sedentary and poor bloodstream. In order to keep the wings physiologically active, the pelicans have to make flight movements regularly. If this would be the case, then *flapping* behaviour could be seen as an adaption to cropped wings which in turn impairs the pelican´s welfare in captivity. However, cropping wings is an irreversible method and cannot be cured by physical enrichment.

Analysis of the results of the undesired behaviours. For ravens and keas undesired behaviours will be discussed with respect to the solitary behaviours: object- and food-exploration. For the pelicans with respect to the solitary behaviour: self-directed and the social behaviour: social locomotion.

Considering the results (see 4.1.), ravens and keas performed following undesired behaviours: *Standing in corner*, *beak-pull* and *pacing.* The pelicans did not perform any of the behaviours, which had been classified as undesired behaviours during the pilot observations at the beginning of the study.

<u>Ravens</u>

Regarding the inductive results (see in 4.2.1.), *Standing in corner* (S.i.c.) was significantly performed less by ravens during the period of enrichment. However, looking at the descriptive results (see in 4.1.2) it is uncertain to what extent the ‘Motorikschleife’ led to the reduction of *S.i.c.*. The low measured percentages of *S.i.c.* (M_{wo} = 0.18; M_{w} = 0.02) suggest that it could be either measured errors. If the enrichment item would have been responsible for a decrease in the performance of *Standing in corner*, it should be accompanied with an increase in the time of *object exploration*. This behavioural pattern stayed constant between both periods, i.e. without and with enrichment. In fact, the measured percentage of *object exploration* resulted from manipulations with natural objects (leaf, tree stump, sticks) whereas not a single contact with the ‘Motorikschleife’ was recorded. The ravens’ refusal of artificial objects can be explained by their high level of neophobia (Heinrich 1988; von Dosky 2016). It was already expected that ravens would need a longer period of time to get used to the enrichment item at the beginning of the study. But it was not expected that their latency to interact with the object would last the whole time of the study. Interestingly, from the date of installing the item on the ground of the aviary, it took the ravens seven days to contact the ground level of the aviary again. The one and only observed indirect contact was as Randall, the male raven, hid food under the slap of the item. As the descriptive results show, ravens spent more time in *food-*

exploration (M_{wo} = 4.76; M_w = 3.64) than in *object-exploration* (M_{wo} = 2.11; M_w = 1.87). Especially caching food was an often performed behaviour within the category *food-exploration*. This behaviour has already been described by Heinrich and colleagues (1998). Also the often described competition within this behaviour pattern was performed by the ravens at Zoo Heidelberg (*agonistic*: M_{wo} = 1.13, *displace*: F_{wo} = 3.28). A singular observation was made as the ravens received mussels for food: Ivan, the female, set the mussel on the sandy ground and held it with one claw. While weighting the claw with her bodyweight and walking on one spot in a circle she buried the mussel in the sand by drilling. After the food was hidden, the corresponding spot was disguised with a natural object (usually a piece of leaf). In addition, washing the food in the standpipe before eating was observed for several times. Since it seems that ravens enrich themselves more with food than with physical objects, food based enrichment should be considered more often. One big advantage of this enrichment method is the subsequent reward which motivates the animal to continue dealing with it (Hosey et al. 2011).

Keas

Within the category of undesired behaviours, the keas performed *Standing in corner (S.i.c.), beak pull* and *pacing.* Like the ravens, the keas' percentage in *Standing in corner* decreased during the period of enrichment, but without showing a significant reduction. For the keas this behaviour can be explained through the direct neighbourhood of the hyacinth-macaws. Nearly all observed *S.i.c.´s* of the keas were the right corner in the back of their enclosure. Behind the back wall there is passage which connects the indoor and outdoor aviary of the macaws. Because of a little hole in the corner on the right, the keas were able to make contact with the macaws and therefore were motivated to stand there. Crustie, the male, even stuffed the hole with food and some objects. The undesired behaviour *beak-pull* only appeared within the keas and showed a decrease after applying physical enrichment. However, the only slight non-significant reduction of 0.2%, in combination with only two study subjects, do not allow the assumption, that the 'Motorikschleife' led to the reduction of this behaviour. Instead, observing *beak-pull* only within the keas can be explained by their foot anatomy. The for parrots typical zygodactyle arrangement of the claws enables the kea to lead its foot to its beak while standing on the other. Furthermore, this special foot anatomy qualifies the kea to grab and climb (Wink and Ferdinand 2014). *Beak-pull* was mostly observed as the kea hung on the fence with one foot on the visitor´s side and pulled its lower mandible with the other one. In contrast, the anisodactyle arrangement of the claws in ravens and pelicans do not allow them to pull on their beaks. Once the causes of these behaviours (*beak pull* and *S.i.c.*) are clarified, it does not make sense to treat them as undesired behaviours. According to the results (see in 4.1.2.), the kea was the only species performing the undesired behaviour *pacing*. This behavioural pattern has always been performed next to a wall/fence of the aviary. The *pacing* behaviour of the keas may be explained by the keas' evolutionary development of their behavioural characteristics. Because of the fast changing environment during Pleistocene glacial climates in New Zealand, the kea was forced -in order to survive- to develop an extreme behavioural flexibility (Temple 1996), which also justifies the species´ high level of neophilia. Living in a consistent environment e.g. in captivity, there is very limited possibility for the kea to execute its behavioural flexibility. Furthermore, an aviary simultaneously limits the keas' territory by forming artificial borders. One possible way to satisfy their requirements for environmental change may then be to pass the fences/walls of the aviary. Thus, *pacing* on walls may be an indication of boredom and unsatisfied curiosity. Sometimes they turn their head about 180° while *pacing*. It appears that this performance acts as a kind of self-enrichment. Mason and Latham (2004) assume, that the performance of stereotypies can be seen as a natural behaviour in a consequence of living in unnatural substrates (e.g. captivity) and helps the animal in dealing with its situation (e.g. stress-relieving). In the period without enrichment the keas could be observed *pacing* for 6.87% of the observation time, whereas they paced for 4.51% of the time with enrichment. At first glance, it seems that the 'Motorikschleife' improved the keas' welfare by reducing the undesired behaviour *pacing* about 2.36%. Nevertheless, the behavioural category *object exploration* also remarkably decreased about 3.87% during the period of enrichment which makes it implausible that the item was responsible for the reduction of *pacing*. In addition, during some of the observation period defined as "without enrichment" the keas still had old shoes inside their enclosure which they had received from the zoo keepers for a couple of weeks before the study had started. The old shoes could not be removed from the enclosure until record session number eleven (day 15 after study start), which had increased the percentage of *object-exploration*. Through the higher percentage in the category *object-exploration* without enrichment it seems that the enrichment success of the old shoes was higher than of the 'Motorikschleife'. In contrast to the 'Motorikschleife', the shoes could be destroyed with their beaks which seems to make them more interesting.

<u>Pelicans</u>

The pelicans spent most of their time in *self-directed* behaviour (M_{wo} = 33.88) and even more (+ 3.47%) within the period of enrichment. As a waterfowl, pelicans have to grease their feathers regularly for maintaining the water repellent characteristics of their plumage (Heinroth 1977). However, in order to exclude the high percentage in performing this behavioural pattern as stereotype, comparisons with wild living conspecifics should be made. Mostly *self-directed* behaviour was observed after the pelicans swam in their standpipe. If swimming was recorded, then they swam as flock and performed the social behaviour: *social locomotion*. As the descriptive results show (see in 4.1.2.) pelicans were the only species performing *social locomotion* (M_{wo} = 10.78) in the period without enrichment. This behavioural pattern can be explained by the pelicans' biology. As a swarm bird, the pelican always orientates itself on its conspecific next to it. Furthermore, their hunting strategy is based on specific swimming formations which cause *social locomotion* for their performance (McMahon and Evans 1992). However, through installing the enrichment item in their standpipe the time of performing *self-directed* behaviour increased (+3.47%) whereas *social locomotion* showed a decrease about 4.02%. In addition, no contact with the enrichment item was observed and the low percentage in *object-exploration* during the period of enrichment resulted from some nibbling on the tree stump in their enclosure. The given percentage shift suggests, that pelicans, like the ravens, could have a certain level of neophobia. In order to avoid contact with the item in the water, the pelicans dispensed for *social locomotion* and replaced this time with preening (*self-directed*) on shore. With regard to undesired behaviours, for pelicans none of them was recorded neither in the period without nor with enrichment which indicates good housing conditions in Zoo Heidelberg. In contrast to ravens and keas, pelicans have another method of enrichment. Through the relatively high number of five animals of this species and the socialisation with other African animals in the enclosure, pelicans enjoy the possibility of social enrichment. Especially the presence of other species provides dynamic and unpredictable sources of stimulation, which may be one of the effective ways of delivering enrichment (Hosey et al. 2011). Furthermore, Spring and colleagues (1997) have shown that social enrichment reduces stereotypes when changings of the environment with objects have failed.

Analysis of the results of the events:

As the results (see in 4.1.3.) show, there are significant differences in the frequencies of *yawn* and *displace* for ravens and pelicans during the period of enrichment. However, through the high error rate, i.e. high variability between subjects, the quality of the data does not allow any interpretations. Considering the frequencies of *displacements* within the ravens, assumptions of the significant reduction (-1.28/h) during the period of enrichment can be made. As already mentioned above, the ravens first ground contact after installing the enrichment item was seven days later. During this time no competitive food caching was possible. Reducing food caching in consequence of their neophobia towards the 'Motorikschleife', led to a reduction in *displacing* each other accordingly.

In the case of scratching behaviour ravens showed the highest rate of all three species before as well as after enrichment. Their frequency can be explained by their unique scratching technique. As a species of the passerines ravens use their claws for dispersing the fat from the beak (originally from uropygial gland) to the head feathers (Heinroth 1977).

Considering the frequencies in *vocalisations* the ravens rate in vocalisations is by far the largest ($M_{wo} = 58.05$; $M_w = 55.04$) in contrast to the keas and pelicans. Within the vocalisations of the ravens there was a large portion in imitations and many repetitions of the same sounds. They usually imitated human language like 'Hallo' or the eagle owl in the aviary next to them. Whether this high rate is an oral stereotype cannot be determined due to a lack of references. The offer of physical enrichment did not lead to a decrease of this high rate. For the pelicans, the extreme low rate in vocalisations ($F_{wo} = 1.19$; $F_w = 0.53$) can be explained by their head anatomy. Because of not having muscles in the syrinx the pelicans repertoire in vocalisations is extremely limited (Hoyo et al. 2009).

Although observations have been made during mating seasons of the birds, no sexual behaviours could be recorded without as well as with enrichment in all three species. For the ravens and keas, it can be explained because of their young age. They should already be mature, but are still too young for breeding. In the case of the pelicans, even though they are more than 25 years old, they had no breeding success. This can be explained by their one cropped wing. Like the flamingos (Rudolph 2013) the male pelicans could get problems during pairing because of not being able to balance on the females back, whereby fertilizations fail.

5.2. Review of the hypotheses

Keas

"Because of the neophilic characteristics of kea (Keller 1975; von Dosky 2016) I hypothesize that they will show high rates of interactions with the new enrichment-item and reduced rates of undesired behaviours" (p. 12).

This hypothesis only partly applies. On one hand the collected data confirms the reduction of undesired behaviours i.e. pacing during the period of physical enrichment. On other hand, the keas did not show an increased percentage of time showing *object-exploration*.

Ravens

"For the ravens I therefore hypothesize that they will show a higher latency to contact and interact with the new enrichment item than the kea. But after establishing contact with the item, I hypothesize that the ravens will also show significant alterations in their daily behaviour and a similar rate of interaction as the kea" (p. 12).

The first hypothesis is not rejected. Since the ravens did not touch the enrichment item a single time during the whole study period, they showed a higher latency than the kea.

The second hypothesis has to be rejected The ravens did not overcome their neophobia to contact the enrichment item and did not show the same percentage in *object-exploration* as the keas. Although the ravens showed some alterations in their daily bird typical behaviours, the percentage in performing in these pattern are too small to make valid statements.

Pelicans

"Compared to the ravens and keas I hypothesize for the pelicans that they will show the least contact with the enrichment item. The behaviours before and after applying the enrichment item will be the same" (p. 12).

This hypothesis only partly applies. Although the pelicans did not show any contact with the enrichment item, the results show that there are trends in some behaviours after applying the enrichment item e.g. social locomotion.

5.3. Discussion of the methods

A general problem with behavioural research is, that the experimenter unconsciously or unwillingly can influence the subjects of research. The experimenter could bias the results he is expecting, this effect is named after Rosenthal (Rosenthal and Fode 1963). The use of standardised methods, which could be repeated by others, tries to circumvent this problem. However, it cannot be excluded.

Validity of data

According to the validity of the data, normal distributions of the single behavioural categories would be better for meaningful results. Therefore, more observation sessions should be made for each species and, if possible more subjects should be observed. Simultaneously, a larger data set would reduce the error rate and increases the data quality. However, through the investigation of three different species temporal expenses would have exceeded the extent of this thesis. One more way to improve the data would be to combine more behavioural patterns within one category. Through the high amount of different behavioural categories in this study, the recorded behaviours scattered too much, whereby data of less performed behaviours can get lost in the statistics. Although it was tried to measure the behaviours of the three different birds uniformly there are many external factors (weather, visitors, size of aviary, daytime etc. …) which could have influenced the birds' behaviours. For gaining optimized data of one species, a certain number of birds have to be kept individually in standardized cages and should be tested on the desired parameters. Though, including external factors and biases, which have a great influence on zoo animals, data collected in a zoo are more realistic in representing an animals state than the optimized data.

To obtain better explanatory power of the data the on use of an enrichment item through the birds, the category *object exploration* should be split up into two: a) exploration with natural objects, b) exploration with artificial objects.

Enrichment methods

In this study only physical enrichment was applied. This method gives the animals the freedom to deal with it or not. Ravens do not seem to be motivated enough to manipulate artificial objects and deal rather with food (natural objects). Another method to enrich animals in captivity is food-based enrichment. Through the subsequent food reward of the action, the animal gets motivated to deal with it. Since the ravens need a high motivation to overcome their neophobia with new objects a combination of both enrichment methods should be considered.

In contrast to the ravens and keas, the pelicans got enriched with less time. The self-made item was installed for 12 days whereas the ravens and keas got enriched for minimally 21 days (3 weeks). If the pelicans have a certain level of neophobia then 12 days of enrichment may be too little for the pelicans as acclimatisation.

5.4. Conclusion and perspective

In conclusion it can be said that the here presented work provides essential behavioural data of birds kept in captivity. Especially the descriptive results show that each single bird species has its own behavioural repertoire in dealing with the housing conditions. Considering the success of enrichment, it can be said that physical enrichment only has a limited effect on the bird´s behaviours. But this does not mean that it should be exclude to use it further. It is intended to encourage further studies to investigate birds’ behaviours by using other methods of enrichment.

In case of the keas an extra study should be considered. Especially the male kea, Crustie, really needs to be monitored in his pacing behaviour. Mason and Latham (2004) managed to significantly reduce stereotypical behaviour in orange-winged amazon parrots through the use of a combination of environmental and food enrichment. In addition, they demonstrated that young parrots reduce their stereotypical behaviour faster than older ones. Both keas housed in Zoo Heidelberg are very young and should receive preventive measures to be able to deal with their live in captivity. Not taking any preventive actions, could reinforce stereotypes and would make them difficult to treat.

Like the ravens, the pelicans did not show any contact with the enrichment item. Because of performing diverse hunting strategies food based enrichment should be considered as well. One possibility in satisfying their hunting drive would be live feeding. However, offering them live fish is forbidden by law. As a remedy to their high performed self-directed behaviour the installation of a water fountain should be considered. By spraying water on their plumage it is easier for them to remove sloughed feathers.

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7. LITERATURE

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Zoo Heidelberg (2016d): Specimen report kea female.

Zoo Heidelberg (2016c): Specimen report kea male.

8. APPENDIX

Measured behaviours of the behavioural states without enrichment

***Tab. 10**: Values of the measured behaviours of ravens without enrichment. The table depicts the states.*

Behaviours	N[5]	M[6]	SD[7]	SE[8]	M [%]	SE [%]
Inactive	25	54,88	28,94	5,79	30,49	3,22
Locomotion	25	29,72	13,66	2,73	16,51	1,52
Alertness	25	34,32	20,59	4,12	19,07	2,29
Object Exploration	25	3,80	5,35	1,07	2,11	0,59
Feeding	25	24,20	14,53	2,91	13,44	1,61
Food Exploration	25	8,56	11,20	2,24	4,76	1,24
Self Directed	25	16,08	29,11	5,82	8,93	3,23
Flapping	25	0,00	0,00	0,00	0,00	0,00
Unexp. Behav.	25	3,76	5,75	1,15	2,09	0,64
Positive	25	2,32	6,13	1,23	1,29	0,68
Social Preening	25	0,00	0,00	0,00	0,00	0,00
Agonistic	25	2,04	4,07	0,81	1,13	0,45
Soc. Locomotion	25	0,00	0,00	0,00	0,00	0,00
Pacing	25	0,00	0,00	0,00	0,00	0,00
Feather Pluck	25	0,00	0,00	0,00	0,00	0,00
Beak Pull	25	0,00	0,00	0,00	0,00	0,00
S.i.c.	25	0,32	0,56	0,11	0,18	0,06
Perch dance	25	0,00	0,00	0,00	0,00	0,00
Not visible	25	0,00	0,00	0,00	0,00	0,00

***Tab. 11**: Values of the measured behaviours of keas without enrichment. The table depicts the states.*

Behaviours	N	M	SD	SE	M [%]	SE [%]
Inactive	25	36,44	35,29	7,06	20,24	3,92
Locomotion	25	34,84	20,29	4,06	19,36	2,25
Alertness	25	13,84	9,12	1,82	7,69	1,01
Object Exploration	25	14,52	19,04	3,81	8,07	2,12
Feeding	25	34,76	41,20	8,24	19,31	4,58
Food Exploration	25	1,40	3,34	0,67	0,78	0,37
Self Directed	25	11,48	11,07	2,21	6,38	1,23
Flapping	25	0,00	0,00	0,00	0,00	0,00
Unexp. Behav.	25	0,48	1,76	0,35	0,27	0,20
Positive	25	4,28	6,07	1,21	2,38	0,67
Social Preening	25	0,92	4,40	0,88	0,51	0,49
Agonistic	25	0,40	0,87	0,17	0,22	0,10

[5] N: Number of observations (à 45 min)
[6] M: Mean-value
[7] SD: Standard deviation
[8] SE: Standard error

Behaviours	N	M	SD	SE	M [%]	SE [%]
Soc. Locomotion	25	0,04	0,20	0,04	0,02	0,02
Pacing	25	12,36	14,64	2,93	6,87	1,63
Feather Pluck	25	0,00	0,00	0,00	0,00	0,00
Beak Pull	25	0,72	1,24	0,25	0,40	0,14
S.i.c.	25	0,32	1,03	0,21	0,18	0,11
Perch dance	25	0,00	0,00	0,00	0,00	0,00
Not visible	25	13,20	17,10	3,42	7,33	1,90

Tab. 12*: Values of the measured behaviours of pelicans without enrichment. The table depicts the states.*

Behaviours	N	M	SD	SE	M [%]	SE [%]
Inactive	25	127,68	113,47	22,69	28,37	5,04
Locomotion	25	78,64	77,22	15,44	17,48	3,43
Alertness	25	21,20	27,07	5,41	4,71	1,20
Object Exploration	25	0,32	0,69	0,14	0,07	0,03
Feeding	25	9,56	13,93	2,79	2,12	0,62
Food Exploration	25	0,48	2,40	0,48	0,11	0,11
Self Directed	25	152,48	117,50	23,50	33,88	5,22
Flapping	25	5,08	7,43	1,49	1,13	0,33
Unexp. Behav.	25	1,00	2,10	0,42	0,22	0,09
Positive	25	3,60	13,15	2,63	0,80	0,58
Social Preening	25	0,12	0,44	0,09	0,03	0,02
Agonistic	25	1,32	2,41	0,48	0,29	0,11
Soc. Locomotion	25	48,52	68,87	13,77	10,78	3,06
Pacing	25	0,00	0,00	0,00	0,00	0,00
Feather Pluck	25	0,00	0,00	0,00	0,00	0,00
Beak Pull	25	0,00	0,00	0,00	0,00	0,00
S.i.c.	25	0,00	0,00	0,00	0,00	0,00
Perch dance	25	0,00	0,00	0,00	0,00	0,00
Not visible	25	0,00	0,00	0,00	0,00	0,00

Measured behaviours of the behavioural states with enrichment

Tab. 13*: Values of the measured behaviours of ravens with enrichment. The table depicts the states.*

Behaviours	N	M	SD	SE	M [%]	SE [%]
Inactive	25	52,48	31,28	6,26	29,16	3,48
Locomotion	25	31,72	16,55	3,31	17,62	1,84
Alertness	25	33,40	23,24	4,65	18,56	2,58
Object Exploration	25	3,36	6,20	1,24	1,87	0,69
Feeding	25	23,64	17,83	3,57	13,13	1,98
Food Exploration	25	6,56	7,67	1,53	3,64	0,85
Self Directed	25	17,60	23,76	4,75	9,78	2,64
Flapping	25	0,00	0,00	0,00	0,00	0,00
Unexp. Behav.	25	3,68	4,91	0,98	2,04	0,55
Positive	25	5,88	13,92	2,78	3,27	1,55

Behaviours	N	M	SD	SE	M [%]	SE [%]
Social Preening	25	0,00	0,00	0,00	0,00	0,00
Agonistic	25	1,64	3,53	0,71	0,91	0,39
Soc. Locomotion	25	0,00	0,00	0,00	0,00	0,00
Pacing	25	0,00	0,00	0,00	0,00	0,00
Feather Pluck	25	0,00	0,00	0,00	0,00	0,00
Beak Pull	25	0,00	0,00	0,00	0,00	0,00
S.i.c.	25	0,04	0,20	0,04	0,02	0,02
Perch dance	25	0,00	0,00	0,00	0,00	0,00
Not visible	25	0,00	0,00	0,00	0,00	0,00

Tab. 14: *Values of the measured behaviours of keas with enrichment. The table depicts the states.*

Behaviours	N	M	SD	SE	M [%]	SE [%]
Inactive	25	50,76	39,55	7,91	28,20	4,39
Locomotion	25	26,72	13,98	2,80	14,84	1,55
Alertness	25	14,68	11,33	2,27	8,16	1,26
Object Exploration	25	7,56	10,56	2,11	4,20	1,17
Feeding	25	41,60	36,02	7,20	23,11	4,00
Food Exploration	25	0,80	2,10	0,42	0,44	0,23
Self Directed	25	16,64	15,09	3,02	9,24	1,68
Flapping	25	0,00	0,00	0,00	0,00	0,00
Unexp. Behav.	25	0,40	0,96	0,19	0,22	0,11
Positive	25	3,44	4,87	0,97	1,91	0,54
Social Preening	25	0,68	2,61	0,52	0,38	0,29
Agonistic	25	0,72	1,59	0,32	0,40	0,18
Soc. Locomotion	25	0,52	2,60	0,52	0,29	0,29
Pacing	25	8,12	10,59	2,12	4,51	1,18
Feather Pluck	25	0,00	0,00	0,00	0,00	0,00
Beak Pull	25	0,36	0,91	0,18	0,20	0,10
S.i.c.	25	0,20	0,65	0,13	0,11	0,07
Perch dance	25	0,00	0,00	0,00	0,00	0,00
Not visible	25	6,80	6,42	1,28	3,78	0,71

Tab. 15*: Values of the measured behaviours of pelicans with enrichment. The table depicts the states.*

Behaviours	N	M	SD	SE	M [%]	SE [%]
Inactive	25	147,64	119,96	23,99	32,81	5,33
Locomotion	25	68,68	74,60	14,92	15,26	3,32
Alertness	25	15,56	22,76	4,55	3,46	1,01
Object Exploration	25	2,40	5,45	1,09	0,53	0,24
Feeding	25	11,36	20,57	4,11	2,52	0,91
Food Exploration	25	1,92	9,60	1,92	0,43	0,43
Self Directed	25	168,08	106,59	21,32	37,35	4,74
Flapping	25	3,00	4,86	0,97	0,67	0,22
Unexp. Behav.	25	0,16	0,47	0,09	0,04	0,02
Positive	25	0,16	0,55	0,11	0,04	0,02

Behaviours	N	M	SD	SE	M [%]	SE [%]
Social Preening	25	0,00	0,00	0,00	0,00	0,00
Agonistic	25	0,64	1,22	0,24	0,14	0,05
Soc. Locomotion	25	30,40	46,56	9,31	6,76	2,07
Pacing	25	0,00	0,00	0,00	0,00	0,00
Feather Pluck	25	0,00	0,00	0,00	0,00	0,00
Beak Pull	25	0,00	0,00	0,00	0,00	0,00
S.i.c.	25	0,00	0,00	0,00	0,00	0,00
Perch dance	25	0,00	0,00	0,00	0,00	0,00
Not visible	25	0,00	0,00	0,00	0,00	0,00

Measured behaviours of the behavioural events without enrichment

Tab. 16*: Values of the measured behaviours of ravens without enrichment. The table depicts the events.*

Behaviours	N	M	SD	SE	F[9] [1/h]	SE (F)
Scratch	25	1,20	1,04	0,21	0,80	0,14
General ruffle	25	5,32	7,98	1,60	3,55	1,06
Vocalisation	25	87,08	61,13	12,23	58,05	8,15
Yawn	25	0,52	0,87	0,17	0,35	0,12
Beek Peel	25	10,24	6,97	1,39	6,83	0,93
Approach	25	0,64	1,15	0,23	0,43	0,15
Sex	25	0,00	0,00	0,00	0,00	0,00
Displace	25	4,92	3,98	0,80	3,28	0,53

Tab. 17*: Values of the measured behaviours of keas without enrichment. The table depicts the events*

Behaviours	N	M	SD	SE	F [1/h]	SE (F)
Scratch	25	0,92	1,04	0,21	0,61	0,14
General ruffle	25	1,76	2,49	0,50	1,17	0,33
Vocalisation	25	32,16	44,28	8,86	21,44	5,90
Yawn	25	1,28	4,97	0,99	0,85	0,66
Beek Peel	25	0,72	1,70	0,34	0,48	0,23
Approach	25	2,68	2,19	0,44	1,79	0,29
Sex	25	0,00	0,00	0,00	0,00	0,00
Displace	25	3,92	3,84	0,77	2,61	0,51

[9] F: Frequency

Tab. 18: *Values of the measured behaviours of pelicans without enrichment. The table depicts the events*

Behaviours	**N**	**M**	**SD**	**SE**	**F [1/h]**	**SE (F)**
Scratch	25	0,84	0,94	0,19	0,22	0,05
General ruffle	25	5,24	4,47	0,89	1,40	0,24
Vocalisation	25	4,48	5,55	1,11	1,19	0,30
Yawn	25	2,48	2,20	0,44	0,66	0,12
Beek Peel	25	0,00	0,00	0,00	0,00	0,00
Approach	25	1,76	4,51	0,90	0,47	0,24
Sex	25	0,00	0,00	0,00	0,00	0,00
Displace	25	0,88	1,39	0,28	0,23	0,07

Measured behaviours of the behavioural events with enrichment

Tab. 19*: Values of the measured behaviours of ravens with enrichment. The table depicts the events*

Behaviours	**N**	**M**	**SD**	**SE**	**F [1/h]**	**SE (F)**
Scratch	25	1,60	2,84	0,57	1,07	0,38
General ruffle	25	4,44	5,12	1,02	2,96	0,68
Vocalisation	25	82,56	71,33	14,27	55,04	9,51
Yawn	25	0,04	0,20	0,04	0,03	0,03
Beek Peel	25	8,76	4,77	0,95	5,84	0,64
Approach	25	1,36	2,66	0,53	0,91	0,35
Sex	25	0,00	0,00	0,00	0,00	0,00
Displace	25	3,00	2,48	0,50	2,00	0,33

Tab. 20: *Values of the measured behaviours of pelicans with enrichment. The table depicts the events*

Behaviours	**N**	**M**	**SD**	**SE**	**F [1/h]**	**SE (F)**
Scratch	25	1,24	1,59	0,32	0,83	0,21
General ruffle	25	1,56	1,80	0,36	1,04	0,24
Vocalisation	25	34,96	42,32	8,46	23,31	5,64
Yawn	25	0,64	1,25	0,25	0,43	0,17
Beek Peel	25	0,60	0,87	0,17	0,40	0,12
Approach	25	2,16	1,93	0,39	1,44	0,26
Sex	25	0,00	0,00	0,00	0,00	0,00
Displace	25	3,88	3,48	0,70	2,59	0,46

Tab. 21: Values of the measured behaviours of pelicans with enrichment. The table depicts the events

Behaviours	N	M	SD	SE	F [1/h]	SE (F)
Scratch	25	0,80	1,08	0,22	0,21	0,06
General ruffle	25	4,00	4,01	0,80	1,07	0,21
Vocalisation	25	2,00	1,89	0,38	0,53	0,10
Yawn	25	1,20	1,50	0,30	0,32	0,08
Beek Peel	25	0,00	0,00	0,00	0,00	0,00
Approach	25	1,04	1,57	0,31	0,28	0,08
Sex	25	0,00	0,00	0,00	0,00	0,00
Displace	25	0,48	0,87	0,17	0,13	0,05

Results of the test for normal distribution of the states: Shapiro-Wilk test

***Tab. 22**: Test for normal distribution for ravens – States. Significands are coloured in red.*

Behaviours	without Enrichment		with Enrichment	
	Shapiro-Wilk W[10]	p[11]	Shapiro-Wilk W	p
Inactive	0,953	0,295	0,941	0,157
Locomotion	0,928	0,857	0,984	0,946
Alertness	0,952	0,270	0,878	0,006
Object Exploration	0,705	0,000	0,584	0,000
Feeding	0,941	0,158	0,930	0,088
Food Exploration	0,779	0,000	0,775	0,000
Self Directed	0,535	0,000	0,717	0,000
Flapping				
Unexp. Behav.	0,692	0,000	0,765	0,000
Positive	0,441	0,000	0,487	0,000
Social Preening				
Agonistic	0,558	0,000	0,533	0,000
Soc. Locomotion				
Pacing				
Feather Pluck				
Beak Pull				
S.i.c.	0,609	0,000	0,203	0,000
Perch dance				
Not visible				

[10] W: value of test statistic
[11] p: p-value (p > 0.05)

***Tab. 23**: Test for normal distribution for keas – States. Significands are coloured in red.*

Behaviours	without Enrichment		with Enrichment	
	Shapiro-Wilk W	p	Shapiro-Wilk W	p
Inactive	0,876	0,001	0,927	0,751
Locomotion	0,919	0,048	0,956	0,340
Alertness	0,941	0,153	0,887	0,010
Object Exploration	0,728	0,000	0,673	0,000
Feeding	0,776	0,000	0,836	0,001
Food Exploration	0,492	0,000	0,436	0,000
Self Directed	0,877	0,006	0,882	0,008
Flapping				
Unexp. Behav.	0,307	0,000	0,494	0,000
Positive	0,732	0,000	0,712	0,000
Social Preening	0,217	0,000	0,286	0,000
Agonistic	0,523	0,000	0,528	0,000
Soc. Locomotion	0,203	0,000	0,203	0,000
Pacing	0,820	0,001	0,773	0,000
Feather Pluck				
Beak Pull	0,652	0,000	0,468	0,000
S.i.c.	0,351	0,000	0,357	0,000
Perch dance				
Not visible	0,773	0,000	0,873	0,005

***Tab. 24**: Test for normal distribution for pelicans – States. Significands are coloured in red.*

Behaviours	without Enrichment		with Enrichment	
	Shapiro-Wilk W	p	Shapiro-Wilk W	p
Inactive	0,898	0,017	0,921	0,055
Locomotion	0,881	0,007	0,802	0,000
Alertness	0,731	0,000	0,696	0,000
Object Exploration	0,521	0,000	0,521	0,000
Feeding	0,714	0,000	0,617	0,000
Food Exploration	0,203	0,000	0,203	0,000
Self Directed	0,925	0,068	0,944	0,180
Flapping	0,711	0,000	0,666	0,000
Unexp. Behav.	0,539	0,000	0,392	0,000
Positive	0,292	0,000	0,308	0,000
Social Preening	0,307	0,000		
Agonistic	0,606	0,000	0,591	0,000
Soc. Locomotion	0,742	0,000	0,695	0,000
Pacing				
Feather Pluck				
Beak Pull				
S.i.c.				
Perch dance				
Not visible				

Results of the test for normal distribution of the events: Shapiro-Wilk test

***Tab. 25**: Test for normal distribution for ravens – Events. Significands are coloured in red.*

Behaviours	without Enrichment		with Enrichment	
	Shapiro-Wilk W	p	Shapiro-Wilk W	p
Scratch	0,870	0,004	0,547	0,000
General ruffle	0,519	0,000	0,681	0,000
Vocalisation	0,935	0,115	0,810	0,000
Yawn	0,626	0,000	0,203	0,000
Beek Peel	0,945	0,197	0,884	0,008
Approach	0,627	0,000	0,573	0,000
Sex				
Displace	0,847	0,001	0,905	0,242

***Tab. 26**: Test for normal distribution for keas – Events. Significands are coloured in red.*

Behaviours	without Enrichment		with Enrichment	
	Shapiro-Wilk W	p	Shapiro-Wilk W	p
Scratch	0,796	0,000	0,789	0,000
General ruffle	0,701	0,000	0,817	0,000
Vocalisation	0,758	0,000	0,776	0,000
Yawn	0,268	0,000	0,583	0,000
Beek Peel	0,478	0,000	0,720	0,000
Approach	0,909	0,029	0,885	0,009
Sex				
Displace	0,850	0,002	0,887	0,001

***Tab. 27**: Test for normal distribution for pelicans – Events. Significands are coloured in red.*

Behaviours	without Enrichment		with Enrichment	
	Shapiro-Wilk W	p	Shapiro-Wilk W	p
Scratch	0,800	0,000	0,737	0,000
General ruffle	0,874	0,005	0,859	0,003
Vocalisation	0,753	0,000	0,853	0,002
Yawn	0,888	0,100	0,756	0,000
Beek Peel				
Approach	0,357	0,000	0,712	0,000
Sex				
Displace	0,696	0,000	0,616	0,000

Protocol Scan Sampling

Name: Felix Braun **Date:** __________ **Time:** __________ **Species:** __________

Weather: __________ **Temperature:** __________ **Institution:** Zoo Heidelberg

	States																		Events								N.V.
	Solitary Behaviours									Social Behaviours				Undesired Behaviours					Solitary Behaviours					Social Behaviours			
Time	I	L	A	O.Exp.	Feed.	F.Exp.	S.Direc.	Flap.	Ux.Bh.	Positiv	S.Pre.	Ago.	Soc.L	Pac.	F.P.	B.Pull.	S.i.c.	P.dac.	Scratch.	G.ruffle	VS	Ywn	B.peel	Appr.	Sex	Displ.	
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Protocol Scan Sampling

Name: Felix Braun______ **Date:**_______________ **Time:** _______________ **Species:** ______________

Weather: ____________ **Temperature:** _________ **Institution:** Zoo Heidelberg

	States																		Events								N.V.
	Solitary Behaviour									Social Behaviour				Undesired Behaviour					Solitary Behaviour					Social Behaviour			
Time	I	L	A	O.Exp.	Feed.	F.Exp.	S.Direc.	Flap.	Ux.Bh.	Positiv	S.Pre.	Ago.	Soc.L	Pac.	F.P.	B.Pull.	S.i.c.	P.dac.	Scratch.	G.ruffle	VS	Ywn	B.peel	Appr.	Sex	Displ.	
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