Coping ability and influencing factors in a zoo population of waldrapp ibises *(Geronticus eremita)*

Waldrapp ibis (BirdLife International, 2016)

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PREFACE

Before you lies the report “Coping ability and influencing factors in a zoo population of waldrapp ibises *(Geronticus eremita)*”. This research was conducted in the framework of our graduation at Van Hall Larenstein University of Applied Sciences. We would like to thank all the people who have helped with this research. In particular we would like to thank our client at GaiaZOO, E. Prins, and our supervisors at Van Hall Larenstein University of Applied Sciences, T. Griede and I. Walstra, who have helped us getting started with the research and supported us during the process. We would also like to thank the zookeepers who opened the research enclosure “Taiga I Volière” for us before the opening hours of the zoo and provided us with information about the individual waldrapp ibises. Finally, we would like to thank Van Hall Larenstein University of Applied Sciences and R. Hofman for letting us borrow the binoculars and telescopes, which were used in order to identify the waldrapp ibises at GaiaZOO.

Jacob Dekker and Cindy Pruppers

Leeuwarden, October 2017

SUMMARY

The waldrapp ibis (*Geronticus eremita*) is a colonial and monogamous bird species, which is classified as 'Critically Endangered' by the International Union for the Conservation of Nature. Due to the rapid decline of wild waldrapp ibises a European Endangered species Programme (EEP) has been set up as one way to preserve this species. The waldrapp ibis may experience difficulties with alternating environments, which could cause problems for the EEP of this species. When the birds are transported for EEP purposes from one zoo to another it is however necessary for the success of the EEP that the birds are able to cope with these new environments. It is of great importance for the EEP that the waldrapp ibises reproduce offspring, which might fail when they are not able to cope with the environment or cope with great difficulty. Furthermore, not being able to cope as well as being able to cope with great difficulty may lead to welfare problems. The aim of this research was to assess the coping ability of fourteen waldrapp ibises in GaiaZOO in relation to their environment and the factors that influence the coping ability. The indicators inactive behaviour, comfort behaviour, reproductive behaviour, feather pecking, enclosure use and health were examined in relation to the factors gender, age, origin, weather condition and temperature. Behavioural data of the fourteen waldrapp ibises at GaiaZOO were collected during 16 days between May and June 2017. The observation method focal animal sampling with continuous recording was used. A total of 147 hours of data was collected, 10.5 hours of data on each waldrapp ibis. Data were prepared and analysed by using the programmes Noldus The Observer, Microsoft Excel 2011 and IBM SPSS 24 in which Linear Mixed Model, the Fisher's exact test and the Chi-square test for homogeneity were used. To determine the overall coping ability, a scoring system was made in which a maximum of two points for each of the six indicators could be scored. At least seven points had to be scored to be considered to cope well with the environment. The results showed that the indicators inactive behaviour and comfort behaviour were affected by the weather condition. However, the lack of active and comfort behaviour during rainy weather seems to be merely a natural reaction and as such does not indicate a poor coping. For the indicator reproductive behaviour ten individuals performed courtship, pair formation and nest building. Furthermore, the results showed that the indicator enclosure use was affected by the factors gender and origin. For the indicator health three individuals had some medical issues. During the observation period no feather pecking was observed. In addition, the results showed that females are better able to cope than males and that certain aspects of the origin influence the coping ability as well. There was no difference in coping ability between young and adult individuals. The aspects of the factor origin can include the social bonding of a group of waldrapp ibises and/or the difference between the housing and husbandry of the origin zoo and the destination zoo. For future introductions it can therefore be advised to get at least five individuals from another zoo. In contrast to the results of this research, other investigations have stated that waldrapp ibises above the age of two have difficulty in coping with new environments. Thus, even though it is not supported by this research it can be recommended to only transfer individuals of two years and younger. In addition, when possible, it can be preferred to transfer female waldrapp ibises rather than males, since females are better able to cope with a new environment. When the gender, age and social bonding of the waldrapp ibises are taken into account for the decision making about transfers it can improve the coping ability of waldrapp ibises in the EAZA collection. The information this research has provided can now be used by the EEP coordinator and the Species Committee as it should help them determine the future management of the waldrapp ibis.

CONTENTS

1 INTRODUCTION

1.1 PROBLEM DESCRIPTION

The waldrapp ibis (*Geronticus eremita*) is a colonial and monogamous bird species that is classified as 'Critically Endangered' by the International Union for the Conservation of Nature since 1994 (Anderson & Robinson, 2012; BirdLife International, 2016). It lives in coastal Morocco, Syria and southern Turkey. Historically, the species occurred in southern Europe, the Middle East and northern Africa, but the wild populations have been declining rapidly for decades, seemingly through habitat loss, persecution, climate change and pesticides. (Serra et al, 2009; Yeniyurt et al, 2016) In 1997, the known wild breeding population was at its lowest point with only 59 breeding pairs (Bowden et al, 2008). Nowadays 200 to 249 mature individuals are living in the wild (BirdLife International, 2016).

A European Endangered species Programme (EEP) has been set up by the European Association of Zoos and Aquaria (EAZA) as one way to preserve this species (EAZA, 2017[a]; EAZA, 2017[b]). An EEP has a coordinator who makes recommendations together with the Species Committee about which animals should breed and which animals should go to which zoo (EAZA, 2017[a]). There are housed about 2000 waldrapp ibises in captivity (WAZA, 2017)

According to the EEP coordinator (personal communication, February 14, 2017), the waldrapp ibis may experience difficulties with alternating environments, which could cause problems for the EEP of this species. In order to maintain a viable population of waldrapp ibises within EAZA member institutions, individuals will have to be moved from one zoo to another. Once they arrive, the animals will attempt to cope with their environment at the new zoo through behavioural and physiological responses (Broom, 1991). The waldrapp ibises may succeed in their attempt to cope with the environment, thus adapting to the environment. It can also be that they succeed with great difficulty. (Broom, 1991) For instance, if the environment is less than optimal for the animals, they can develop stereotypic behaviour (Shepherdson et al, 1998). Stereotypies are repetitive, invariant behaviour patterns with no obvious goal or function (Mason, 1991). In addition there is the possibility that the waldrapp ibises are not able to cope with the environment at all, in which case their fitness is reduced (e.g. death, failure to grow, failure to reproduce) (Broom, 1991). This is the worst-case scenario, since it is of great importance for the EEP that the animals reproduce offspring. Both when the waldrapp ibises are not able to cope with the environment and when they have great difficulty in coping with the environment there is a case of poor welfare (Broom, 1991). Four of the five freedoms of animal welfare are namely at risk if an animal is unable to cope with the environment (freedom from discomfort, freedom from pain, injury and disease, freedom from fear and distress and freedom to express natural behaviours) (Hosey et al, 2012).

A poor welfare may be reflected in health problems and abnormal inactive behaviour (Broom 1986; Broom, 1988). A research by Vargas-Ashby & Pankhurst (2007) points out that a healthy amount of inactive behaviour for waldrapp ibises during daytime would be around 35% of the time, whereas 60% of the time spend on inactive behaviour would be unhealthy. Meanwhile, animals that experience good welfare are more likely to perform comfort behaviours, which include a group of behaviours that are thought to be involved in body maintenance (Mills & Marchant-Forde, 2010). There have been some studies that suggest that a normal amount of time spend on comfort behaviour during the day for waldrapp ibises in captivity lies around 25% (Vargas-Ashby & Prankhurst, 2007; Walther & Clayton, 2005). It has also been stated that if the waldrapp ibises fail to cope with the environment their reproductive success might be hampered (Broom, 1991), which might already be visible by abnormalities in -or total absence of reproductive behaviour such as courtship, nest building and copulation. Waldrapp ibises reach sexual maturity within three years of age (Sorato &

Kotrschal, 2006). When individuals of two years old have an experienced older partner, reproduction can take place (Bowden, 2015). Their courtship behaviour includes mutual head-bowing, mutual preening, offering of nest material, and bill shaking (Boehm, 2006). As males can use nest sites and nest material to attract a female, courtship and pair formation are associated with nest building (Soler et al, 1998). They prefer nesting on ledges in steep rocks or cliffs and will also use artificial ledges, preferably covered ledges. Nest building starts in February and they are built of short branches and softer material as dry grass. (Boehm, 2006; IAGNBI, 2017[a]) Two to four eggs are laid between March and May, which are incubated for 24-28 days. Both parents take care of the young, which fledge at 50 days after hatching. (Sorato & Kotrschal, 2006) When the waldrapp ibises fail to cope with the environment they might show stereotypic behaviour. A common stereotypic behaviour in captive birds is feather pecking, which includes both when a bird pecks its own feathers and when it pecks feathers of another bird. (Grindlinger, 1991) There is a strongly supported hypothesis that states that by performing stereotypic behaviour the animal has found a way to cope with a suboptimal environment (Shepherdson et al, 1998). But even though it can help an individual to cope with the environment, it still is an indication that its welfare is not as good as that of another animal that does not have as much difficulty in coping (Broom, 1991). According to Broom (1983), animals that perform more than 10% of their time on stereotypic behaviour experience a poor welfare. A poor welfare can also be reflected in the way the waldrapp ibises use the enclosure, as it provides information about how the enclosure works for the animals (Hosey et al, 2012; Ross et al, 2009). If the waldrapp ibises fail to cope with their environment they are more likely to hide away (Wechsler, 1995). So inactive behaviour, comfort behaviour, reproductive behaviour, feather pecking, enclosure use and health of the waldrapp ibises can be used as indicators of coping ability.

Individuals might respond differently to the enclosure. Individual differences (gender, age) as well as individual differences in experience (origin) are factors which are likely to play a role in their coping ability. Since the weather condition and temperature can affect the indicators of coping, as for instance cold temperatures and rain reduce the activity of waldrapp ibises, these are also important factors to consider when assessing the coping ability (IAGNBI, 2017[b]).

In 2016, GaiaZOO started with keeping of the waldrapp ibis, receiving fourteen in total (seven males and seven females) from three different zoos. They are currently housed in a large mixed species walkthrough aviary. GaiaZOO receives circa 500.000 visitors annually and houses approximately 135 different species, with a total of circa 1.500 individuals (GaiaZOO, 2017). The waldrapp ibises of GaiaZOO have to cope with their environment to ensure good animal welfare. Furthermore it is meaningful for the EEP coordinator to know which factors can influence the coping ability of waldrapp ibises as this can help in making decisions about which waldrapp ibises should move to another zoo. Thus, a research was conducted, on behalf of GaiaZOO, in order to find out (1) whether their waldrapp ibises are successful in their coping and (2) which factors might influence their coping ability.

1.2 AIM OF THE RESEARCH

The aim of this research is to assess the coping ability of the waldrapp ibises in GaiaZOO in relation to their environment and the factors that influence their coping ability.

1.3 RESEARCH QUESTIONS

The main research question is:
How do the waldrapp ibises at GaiaZOO cope with their environment and which factors influence their coping ability?

In order to get an answer to this question, it is split in several sub-questions:

1. How much time do the waldrapp ibises spend on inactive behaviour?
2. How much time do the waldrapp ibises spend on comfort behaviour?
3. How many waldrapp ibises perform the reproductive behaviours courtship, pair formation and nest building?
4. How much time do the waldrapp ibises spend on feather pecking?
5. How do the waldrapp ibises use the enclosure?
6. How many waldrapp ibises are healthy?
7. How do the factors gender, age, origin, weather condition and temperature influence the coping ability of the waldrapp ibises?

2 MATERIAL AND METHODS

2.1 RESEARCH POPULATION

The research population consisted of fourteen waldrapp ibises (seven males and seven females) housed in a mixed species walkthrough aviary, called the Taiga I Volière, in GaiaZOO. These birds came from three different zoos during the spring and summer of 2016; two females originated from zoo 1 (March 2016), all seven males had zoo 2 as origin (May 2016), and the other five females originated from zoo 3 (July 2016). The ages of these waldrapp ibises ranged from 1 to 7 years at the end of the study. The birds could be distinguished by their leg bands. (Table 1)

Table 1: Research population behavioural study waldrapp ibises at GaiaZOO.

House number	Local ID	Sex	Birth date	Age	Origin	Leg band
Gaia 1	B15082	F	01-05-2015	2	Zoo 1	White EF
Gaia 2	B15083	F	01-05-2015	2	Zoo 1	Green DC
Gaia 3	B15257	M	22-05-2015	2	Zoo 2	Red DC
Gaia 4	B15258	M	20-05-2015	2	Zoo 2	Red BS
Gaia 6	B11187	M	09-05-2011	6	Zoo 2	Red TC
Gaia 7	B11188	M	27-04-2011	6	Zoo 2	Red CA
Gaia 8	B10189	M	13-05-2010	7	Zoo 2	Red LA
Gaia 9	B15267	M	05-05-2015	2	Zoo 2	Red T7
Gaia 15	B16523	M	~26-04-2016 to 30-04-2016	1	Zoo 2	Red JL
Gaia 10	B10390	F	19-05-2010	7	Zoo 3	Green B7
Gaia 11	B10391	F	19-05-2010	7	Zoo 3	Green BL
Gaia 12	B11387	F	24-05-2011	6	Zoo 3	Green FJ
Gaia 13	B11388	F	17-05-2011	6	Zoo 3	Green AH
Gaia 14	B11389	F	17-05-2011	6	Zoo 3	Green FD

2.3 RESEARCH ENCLOSURE

The Taiga I Volière is a mixed species walkthrough aviary and has a dimension of 50,0m x 32,0m x 12,5m (= 1.600m^2 & 20.000m^3). The area contains water, grass, arid areas, trees, shrubs, rocks, pebbles, nest boxes, perches, a roof, and a visitor's path (Figure 1). At the start of the data collection the enclosure had just been opened for public, after the compulsory indoor confinement, so zoo visitors were able to walk through the aviary between 10:00 and 17:00 every day. The waldrapp ibises were housed together with cheer pheasants (*Catreus wallichii*), tufted ducks (*Aythya fuligula*), baers pochards (*Aythya baeri*), marbled teals (*Marmaronetta angustirostris*), white headed ducks (*Oxyura leucocephala*), northern shovelers (*Spatula clypeata*), baikal teals (*Sibirionetta formosa*), redshanks (*Tringa tetanus*), rock doves (*Columba livia*), demoiselle cranes (*Anthropoides virgo*), stone curlews (*Burhinus oedicnemus oedicnemus*), pied avocets (*Recurvirostra avosetta*), cinereous vultures (*Aegypius monachus*), griffon vultures (*Gyps fulvus*), a western Egyptian vulture (*Neophron percnopterus percnopterus*), European rollers (*Coracias garrulous*), lesser kestrels (*Falco naumanni*) and azure-winged magpies (Cyanopica cyanus cyanus).

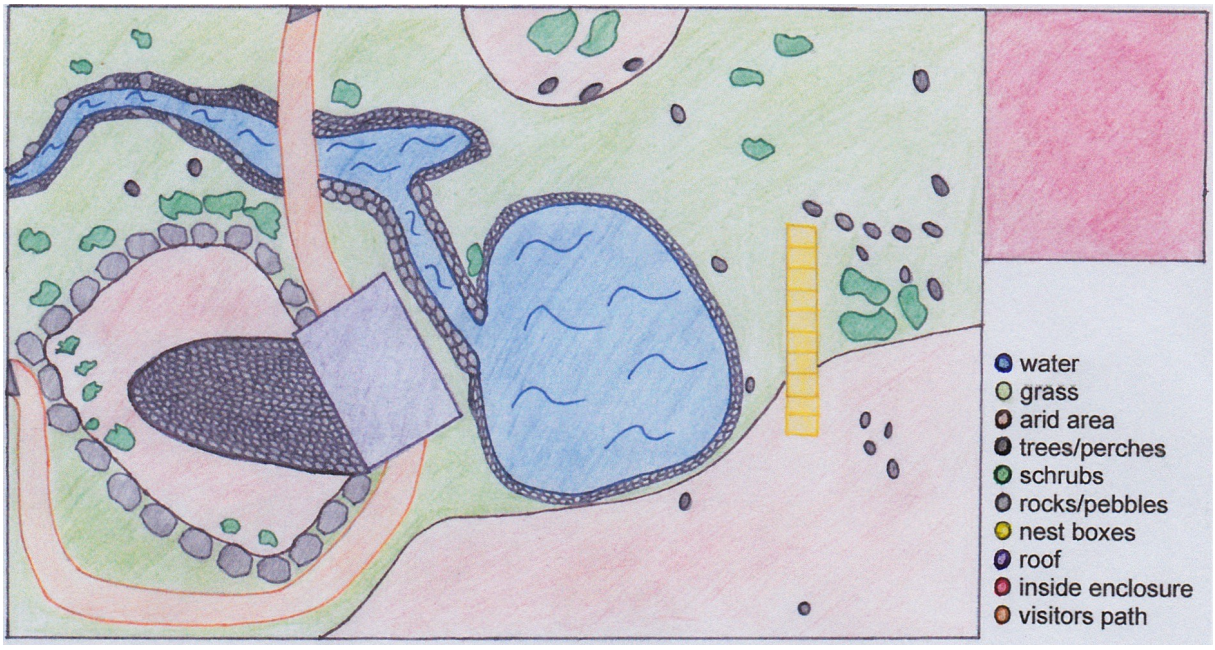

Figure 1: Research enclosure behavioural study waldrapp ibises at GaiaZOO.

In order to determine the enclosure use the aviary was divided into eleven zones (Figure 2).

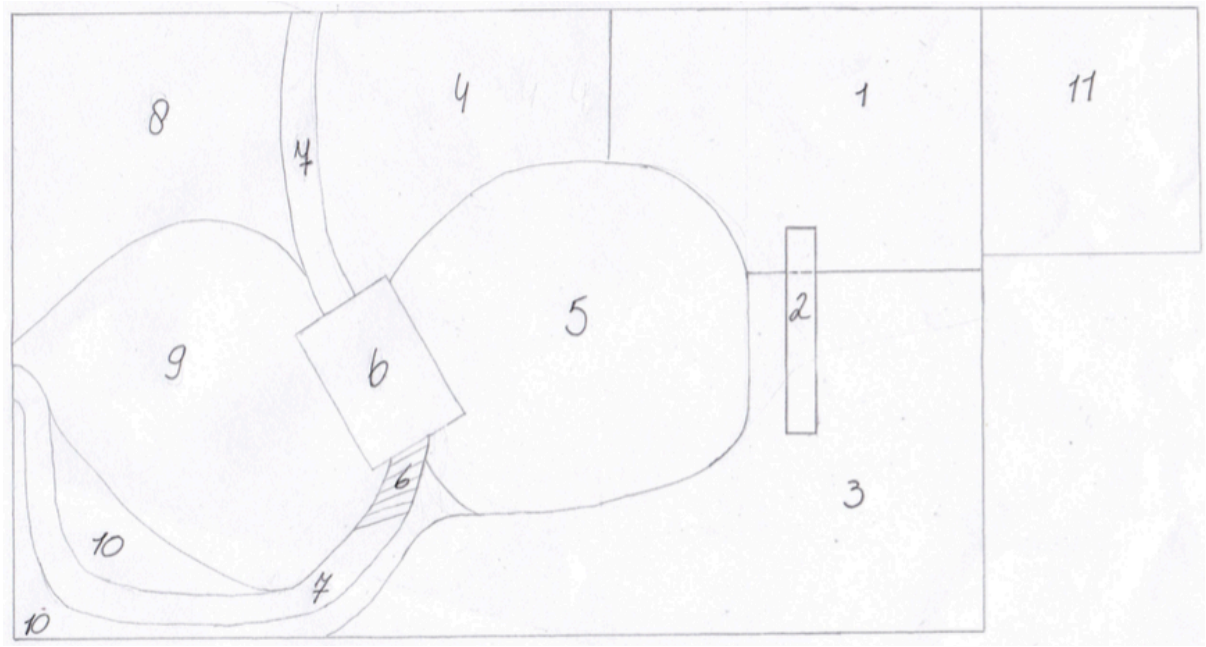

Figure 2: Zones research enclosure behavioural study waldrapp ibises at GaiaZOO.

Figures 3 to 13 show the actual sections of the Taiga I Volière as they were in GaiaZOO as of June 2017.

Figure 3: Taiga I Volière GaiaZOO zone 1: grass, shrubs, trees and perches.

Figure 4: Taiga I Volière GaiaZOO zone 2: nest boxes.

Figure 5: Taiga I Volière GaiaZOO zone 3: higher ground with grass, shrubs, arid area, trees and perches.

Figure 6: Taiga I Volière GaiaZOO zone 4: grass, rocks, pebbles and water.

Figure 7: Taiga I Volière GaiaZOO zone 5: water body surrounded by rocks, pebbles, grass, arid area, trees and perches. Feeding area waldrapp ibis.

Figure 8: Taiga I Volière GaiaZOO zone 6: the roof.

Figure 9: Taiga I Volière GaiaZOO zone 7: visitors' path.

Figure 10: Taiga I Volière GaiaZOO zone 8: grass, shrubs, rocks, pebbles, water, trees and perches.

Figure 11: Taiga I Volière GaiaZOO zone 9: arid area, rocks and pebbles. Feeding area vultures.

Figure 12: Taiga I Volière GaiaZOO zone 10: grass, shrubs, trees and perches.

Figure 13: Taiga I Volière GaiaZOO zone 11: inside area.

2.4 DATA COLLECTION

Behavioural data of the fourteen waldrapp ibises at GaiaZOO were collected during 16 days between May and June 2017, using the ethogram in Table 2. Observations were done in three time periods of 105 minutes (10:15-12:00, 12:30-14:15, 14:45-16:30). These three periods were selected to best replicate the division of daytime activity that would be seen in the wild. Waldrapp ibises are most active late in the morning (between 10:00-12:00) and during the late afternoon (15:00-17:00) (IAGNBI, 2017[b]). During midday they are inactive for one to two hours (IAGNBI, 2017[b]). During each of these time periods each observer followed a different individual, so that on each day six individuals were observed. The birds were

distinguished by their leg bands (Table 1). Since their leg bands were very small, a telescope and binoculars were used in order to identify the birds.

Table 2: Ethogram behavioural study waldrapp ibises at GaiaZOO.

Behaviour	Code	Description
Inactive	IA	The bird does not perform any active behaviour and remains stationary (lying, sitting, standing, sunbathing).
Locomotion	LO	The bird is performing one of the locomotion behaviours flying, walking, hopping, running, or jumping. Foraging is also included.
Comfort	CO	The bird performs one of the comfort behaviours preening, scratching, body shaking, bill/head rubbing, bathing, or sunbathing.
Reproductive	RE	The bird performs one of the reproductive behaviours courtship, nest building, copulation, incubation, brooding, nest maintenance, nest defending, or chick feeding.
Feather pecking	FP	The bird is pecking feathers of it's own plumage or of the plumage of another bird.
Other	OT	The bird performs active behaviour other than the ones described above.
Not visible	NV	The bird is not visible.

The observation method used was focal animal sampling with continuous recording (Martin & Bateson, 2007). This method was chosen because a complete overview could be obtained of the amount of time the individual waldrapp ibises spent on the different behaviours. Beside this, the method was very suitable to assess if the factors gender, age and origin had an influence on the coping ability of the waldrapp ibises. A random observation scheme was made (appendix I) and the behaviours were registered using the programme Noldus Pocket Observer (Noldus software, Wageningen, The Netherlands) (after this called 'Pocket Observer') on a smartphone. In total, each individual was observed twice on each time period, which resulted in a total of 147 hours of data, 10.5 hours of data on each individual waldrapp ibis.

Also the indicator enclosure use was examined during the behavioural study. The section in which the observed waldrapp ibis occurred at the beginning of the time period was registered in the Pocket Observer and every time when the bird moved to another zone this was also registered. Furthermore, the indicator health was investigated by medical data in the Zoological Information Management System (ZIMS) (Species 360, Bloomington, MN, United States) from the moment the waldrapp ibises arrived at GaiaZOO until the last observation day.

Additionally, the factors that could influence the indicators were registered on a datasheet for each observation (appendix II). These factors were gender (male, female), age (young: 1-2 years, adult: 6-7 years), origin (zoo 1, zoo 2, zoo 3), weather condition (sunny, partly cloudy, cloudy, rainy) and temperature in °C (determined by the KNMI website (KNMI, 2017)). The most frequent weather condition during each observation was registered. Temperature was determined at the beginning and at the end of each observation, and after this the mean temperature of the observation was calculated.

2.5 DATA PREPARATION

Data were prepared by using the programmes Noldus The Observer XT11 (after this called 'The Observer'), Microsoft Excel 2011 (Microsoft software, Redmond, WA, United States) (after this called 'Excel') and IBM SPSS 24 (IBM software, Brussels, Belgium) (after this called 'SPSS'). Data in the Pocket Observer were exported towards The Observer and after this towards Excel. In order to determine how much time the waldrapp ibises spent on the different behaviours and in each zone these data were corrected for not visible. After this, percentages of time the waldrapp ibises were spending per behaviour type and in each zone were calculated per observation. Data on the datasheet were also entered into the Excel file.

Data were exported towards SPSS and were further prepared for conducting statistical analyses.

In order to determine the enclosure use of the waldrapp ibises also the section sizes had to be determined. This was done by laying a grid over the map in figure 2.

2.6 DATA ANALYSIS

To analyse if the factors gender, age, origin, weather condition and temperature influenced the indicators inactive behaviour, comfort behaviour and enclosure use the analysis Linear Mixed Model (LMM) in SPSS was used. This analysis is suitable when more observations are done on the same individuals. Since the factors gender and age were not evenly distributed over the three origins, these three factors could not exist in the same model. So for each indicator one model was made for the factors gender, age, weather condition and temperature and another model was made for the factors origin, weather condition and temperature. To analyse if the factors gender and age influenced the indicators reproductive behaviour and health the fisher's exact test was used. Furthermore, to analyse if the factor origin influenced these two indicators the Chi-square test for homogeneity was used. Weather condition and temperature could not be investigated for the indicators enclosure use, reproductive behaviour and health, because only one value was determined over the entire observation period. The values would be the same for all individuals. The significance level was set at $p<0.05$.

The enclosure use of the waldrapp ibises was determined by a formula derived from the formula for the modified Spread of Participation Index (SPI), which allows for unequal section sizes (Plowman, 2003). This formula is as follows:

$$Enclosure\ use\ index = \frac{\sum |fo - fe|}{2(1 - fe\ min)}$$

In this formula fo is the proportion of time a waldrapp ibis spent in a specific section, while fe is the expected proportion of time spent in a section, adjusted to section size, if there would be made evenly use of the entire enclosure. The sum of the absolute values of the difference between fo and fe for all zones is expressed by $\sum |fo - fe|$. Furthermore is in the formula $fe\ min$ the expected proportion of time spent in the smallest zone if there would be made evenly use of the enclosure. The enclosure use index provides a number between 0 and 1, with a number of 0 meaning that the observed proportion of time spent in all zones is equal to the expected proportion of time spent in all zones when section size is taken into account, while a value of 1 indicates that only the smallest section of the enclosure is used. The enclosure use index was calculated per individual for the entire observation period. If the enclosure use index was measured per observation this led probably to an underestimation of the overall enclosure use, as individuals were not seen in the same zones each observation. For the calculation zones 7 and 11 were not included. Zone 7 was not included, because it consists of the visitors' path and the waldrapp ibises are not allowed to be there. Zone 11 was not included, because this is the indoor section and waldrapp ibises in this section were most of the time not visible. Therefore it could not always be determined whether an ibis was in zone 11 or merely not visible in another zone. So the observed time spent in zone 11 is probably an underestimation.

Finally, in order to determine whether the waldrapp ibises in GaiaZOO cope with their environment a scoring system was created, in which two, one or zero points could be scored for each of the six indicators. The scores that were given are based on a value for good coping derived from literature. The more points a group of individuals scores for all six indicators the better the group is able to cope with the environment. In this scoring system a maximum score of twelve points could be obtained. A group of individuals had to score at least seven points to be considered to cope well with the environment. (Table 3)

Table 3: Scoring system coping ability behavioural study waldrapp ibises at GaiaZOO.

Indicator	Norm	Points
Inactive behaviour	35% of the time spent on inactive behaviour (Vargas-Ashby & Pankhurst, 2007)	<20% = 0 20-30% = 1 30-40% = 2 40-50% = 1 >50% = 0
Comfort behaviour	25% of the time spent on comfort behaviour (Vargas-Ashby & Pankhurst, 2007; Walther & Clayton, 2005)	<10% = 0 10-20% = 1 20-30% = 2 30-40% = 1 >40% = 0
Reproductive behaviour	Courtship, pair formation and nest building occurred in >80% of the individuals.	>80% = 2 60-80% = 1 <60% = 0
Feather pecking	<10% of the time spent on feather pecking (Broom, 1983)	0-5% = 2 5-10% = 1 >10% = 0
Enclosure use	Enclosure use index of 0-0.2 (Downes, 2012)	0-0.2 = 2 0.2-0.5 = 1 >0.5 = 0
Health	>80% of the individuals healthy	>80% = 2 60-80% = 1 <60% = 0

For the indicators inactive behaviour and comfort behaviour good coping was experienced if the actual result did not deviate more than 5% from the norm (= 2 points). In addition bad coping was experienced for these two indicators if the actual results deviated more than 15% from the norm (= 0 points).

Since it was the first breeding season the waldrapp ibises had to habituate to each other, there was looked into the behaviours courtship, pair formation and nest building instead of reproductive success. As reproduction can take place in individuals from two years old the young individuals were included as well, with exception of one individual (Bowden, 2015). As generally a successful animal is considered to be one that is able to get its genetic material to the next generation and a failure to cope can hamper the reproductive success (Hosey, 2012; Broom, 1991), it was decided to set this percentage high. It was rated as good coping if more than 80% of the individuals in a group were building a nest (= 2 points). It was rated as bad coping if less than 60% of the individuals were building a nest as the reproductive success in the wild fluctuates a lot between years (= 0 points) (Bowden et al, 2008).

For feather pecking the norm stated that a poor welfare was experienced when waldrapp ibises spent more than 10% of the time on this behaviour (Broom, 1983) (= 0 points). As Broom & Johnson (1993) state that good welfare is experienced when only occasional feather pecking caused by minor frustration occurs it was rated as good coping when less than 5% of the time was spent on feather pecking (= 2 points).

For the enclosure use the norm stated that a score between 0 and 0.2 is a good score (Downes, 2012) (= 2 points). As the enclosure consists of many different structures and individuals might have developed preferences for specific locations in the enclosure the results had to sit quite a bit above the norm in order to rate it as bad coping. Therefore it was rated as bad coping if the individuals scored an enclosure use index of 0.5 or above (= 0 points).

For the indicator health it was rated as good coping if more than 80% of the individuals in a group experienced a good health (= 2 points). A good health is necessary for good animal welfare (Hosey, 2012), though still recognizing that a poor health may occasionally occur by coincidence. It was rated as bad coping if less than 60% of the individuals experienced a good health (= 0 points).

3 RESULTS

To gain insight into the coping ability and factors that influence the coping ability of the waldrapp ibises in GaiaZOO, the fourteen waldrapp ibises were observed for 16 days between May and June 2017. This resulted in a total of 147 hours of data, 10.5 hours of data per individual. The indicators inactive behaviour, comfort behaviour, reproductive behaviour, feather pecking, enclosure use and health were examined in relation to the factors gender, age, origin, weather condition and temperature.

3.1 INACTIVE BEHAVIOUR

The group of waldrapp ibises spent on average 41.6% of the observed time on inactive behaviour. Inactive behaviour was found to be significantly affected by weather condition (LMM: $F(3.73)=4.055$, $p=0.010$), individuals spending significantly more time performing inactive behaviours on rainy days compared to sunny ($p=0.010$) and partly cloudy ($p=0.021$) days (Figure 14).

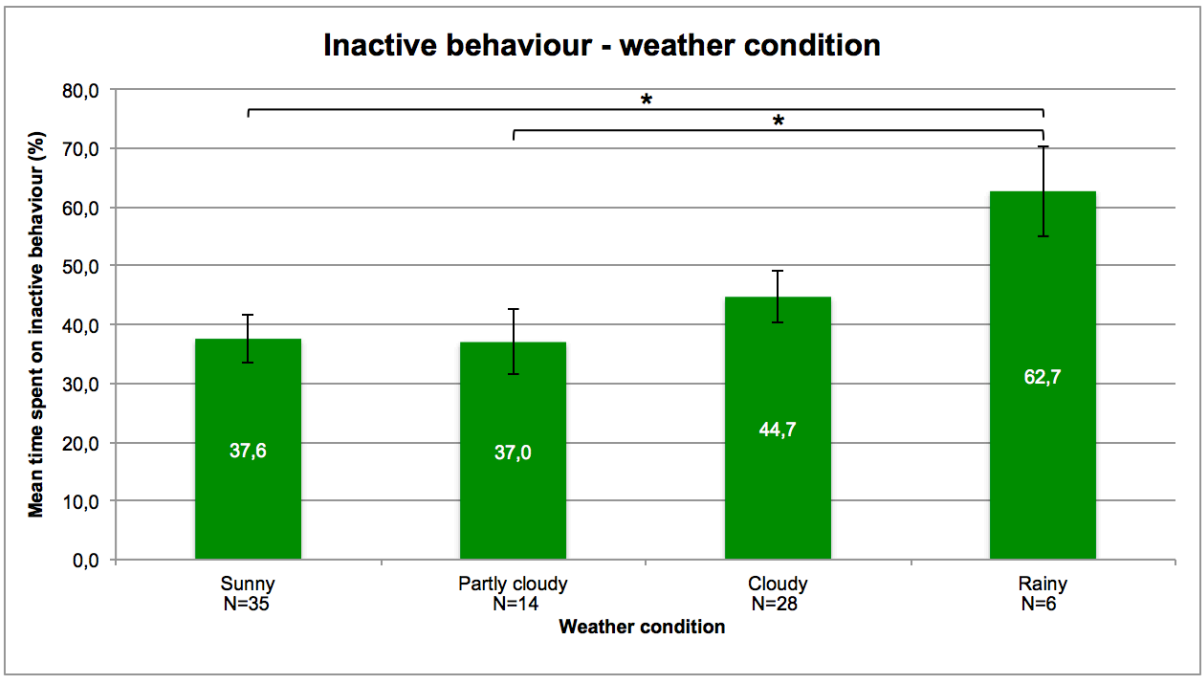

Figure 14: Mean percentage of time spent on inactive behaviour per weather condition. Labels in the bars indicate the percentages, N is the number of observations, * means p<0.05.

3.2 COMFORT BEHAVIOUR

The group of waldrapp ibises spent on average 23.8% of the observed time on comfort behaviour. Comfort behaviour was found to be significantly affected by weather condition (LMM: $F(3.83)=7.570$, $p<0.001$), individuals spending significantly more time performing comfort behaviours on sunny days compared to cloudy ($p<0.001$) and rainy ($p=0.018$) days (Figure 15).

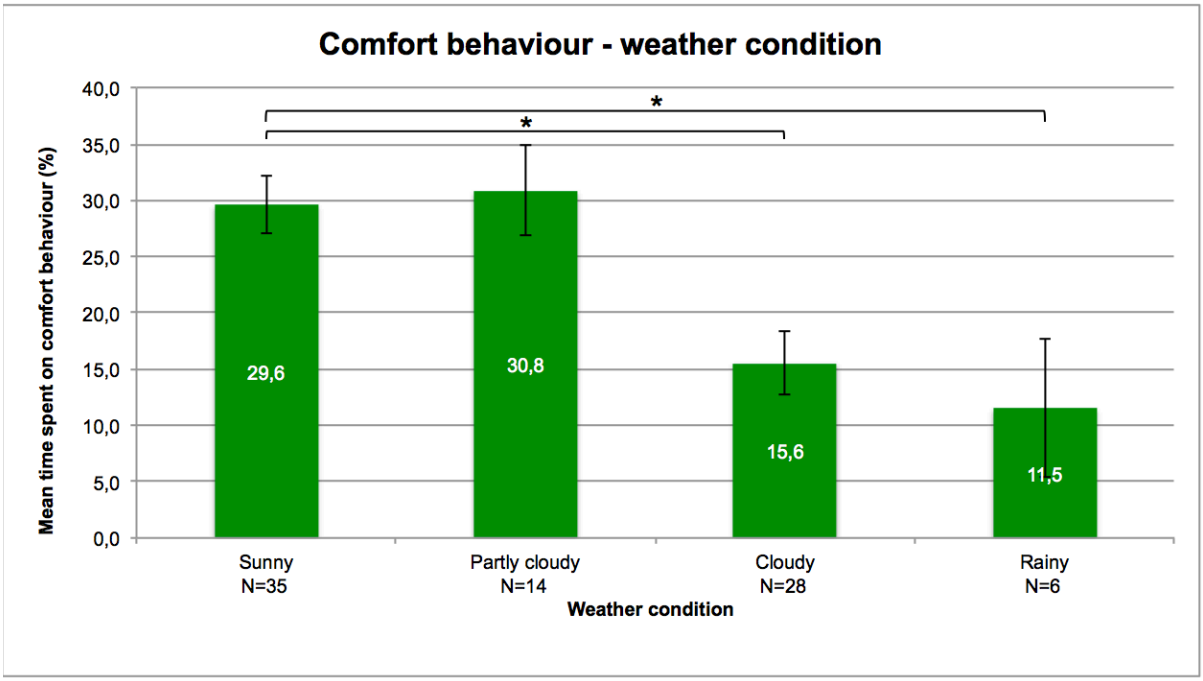

Figure 15: Mean percentage of time spent on comfort behaviour per weather condition. Labels in the bars indicate the percentages, N is the number of observations, * means p<0.05.

Furthermore, comfort behaviour was found to be significantly affected by the interaction between age and weather condition (LMM: F(3.83)=3.557, p=0.018), whereby young individuals spent more time performing comfort behaviours during sunny and rainy days, and adult individuals spent more time performing comfort behaviours during partly cloudy and cloudy days (Figure 16).

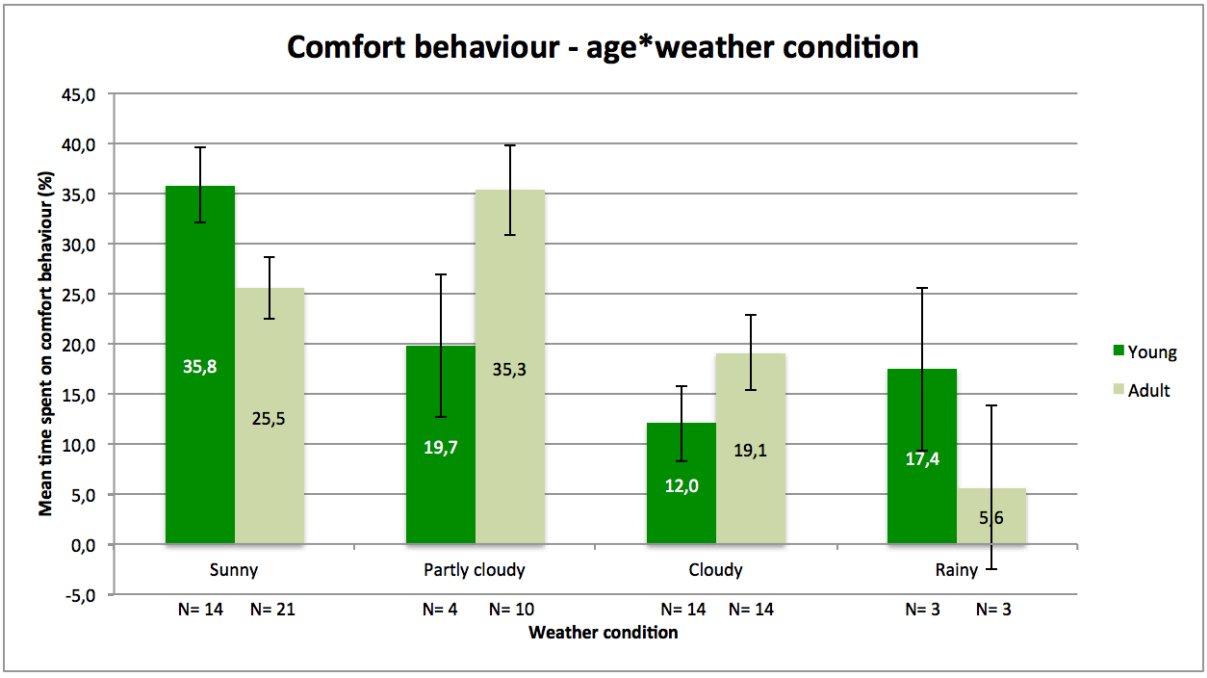

Figure 16: Mean percentage of time spent on comfort behaviour per weather condition for both age classes. Labels in the bars indicate the percentages, N is the number of observations.

3.3 REPRODUCTIVE BEHAVIOUR

The reproductive behaviours courtship, pair formation and nest building were performed by ten of the thirteen waldrapp ibises of two years and older (76.9%). Three males and five females were sexually mature. In total five pairs were formed. Two of the five pairs consisted of a sexual mature male and female. Three pairs had at least one immature bird and two of these pairs were homosexual. Only one of the five pairs built a successful nest. Three eggs were laid and all of them hatched. One egg was discovered in another nest box, but since the nest box was often occupied by a homosexual pair it was probably not fertilized. This egg had disappeared five days after discovery.

3.4 FEATHER PECKING

No feather pecking was observed.

3.5 ENCLOSURE USE

The group of waldrapp ibises had a mean enclosure use index of 0.45. Enclosure use was found to be significantly affected by gender (LMM: F(1.14)=7.573, p=0.016), females made significantly more use of the available space than males (Figure 17).

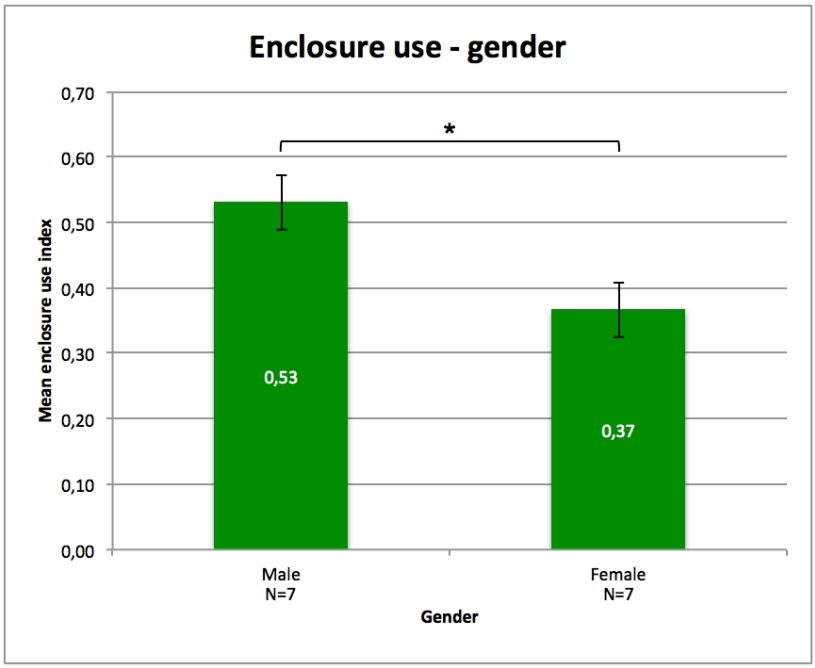

Figure 17: Mean enclosure use index per gender. Labels in the bars indicate the indexes, N is the number of observations, * means p<0.05.

Furthermore, enclosure use was found to be significantly affected by origin (LMM: F(2.14)=4.185, p=0.038), individuals from zoo 2 made less use of the available space than individuals received from zoo 1 and zoo 3 (Figure 18).

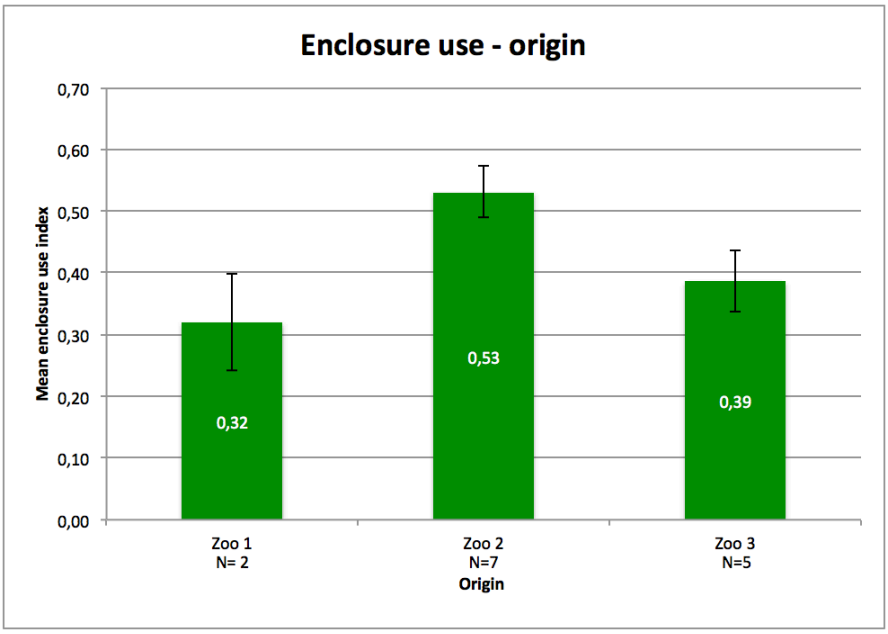

Figure 18: Mean enclosure use index per origin. Labels in the bars indicate the indexes, N is the number of observations.

3.6 HEALTH

Of the group of waldrapp ibises 78.6% was healthy. Eleven of the fourteen waldrapp ibises had empty medical records since they arrived at GaiaZOO. Three birds have had some medical issues. A young male from zoo 2 has been limping with its left leg at least since the start of the observations. An adult male from zoo 2 lost a part of the wing in April 2017 and a month later the edge of the other wing had broken off. After both incidences the bird was kept indoors for a few days until the wounds had healed. This waldrapp ibis is incapable of flying more than a few meters. In June 2017 a young female from zoo 1 seemed weak and was very skinny. After a few days separated indoors the bird was released again in the aviary and has been seen eating well. (ZIMS, 2017)

3.7 COPING ABILITY

Averages were calculated for each indicator for the factors gender, age and origin. These averages were compared with the norms in table 3 and corresponding scores were awarded. At least seven points had to be obtained by each group of individuals to be considered to be coping well. Females have a higher coping ability score than males and waldrapp ibises from zoo 3 have a higher coping ability score than individuals received from zoo 1 and zoo 2. There was not found a difference in coping ability between the two age classes. (Table 4) Weather condition influences the coping ability of the waldrapp ibises, temperature did not.

Table 4: Coping ability waldrapp ibises GaiaZOO, based on the indicators inactive behaviour, comfort behaviour, reproductive behaviour, feather pecking, enclosure use and health, for the factors gender, age and origin.

Factor	Value	Mean time spent on inactive behaviour (%)	Pts	Mean time spent on comfort behaviour (%)	Pts	Individuals performed courtship + pair formation + nest building (%)	Pts	Mean time spent on feather pecking (%)	Pts	Mean enclosure use index	Pts	Healthy Indivi-duals (%)	Pts	Total Pts
Gender	Male	48.1%	1	23.5%	2	83.3%	2	0.0%	2	0.53	0	71.4%	1	8
	Female	42.1%	1	20.3%	2	71.4%	1	0.0%	2	0.37	1	85.7%	2	9
Age	Young	42.1%	1	21.6%	2	80.0%	2	0.0%	2	0.39	1	66.7%	1	9
	Adult	48.1%	1	22.2%	2	75.0%	1	0.0%	2	0.50	1	87.5%	2	9
Origin	Zoo 1	43.2%	1	16.7%	1	50.0%	0	0.0%	2	0.32	1	50.0%	0	5
	Zoo 2	47.6%	1	23.6%	2	83.3%	2	0.0%	2	0.53	0	71.4%	1	8
	Zoo 3	43.5%	1	22.0%	2	80.0%	2	0.0%	2	0.39	1	100.0%	2	10

4 DISCUSSION AND CONCLUSION

The aim of this research was to assess the coping ability of the waldrapp ibises in GaiaZOO in relation to their environment and the factors that influence the coping ability. The investigations have provided information on the indicators inactive behaviour, comfort behaviour, reproductive behaviour, feather pecking, enclosure use and health and the way these are influenced by the factors gender, age, origin, weather condition and temperature. With this information the coping ability and the factors influencing it could be assessed and thus is the research goal achieved.

Inactive behaviour of the waldrapp ibises was influenced by weather condition as they were less active during rainy weather. This finding is in line with literature as Boehm (2006) states that rain reduces the activity of waldrapp ibises. Furthermore the mean percentage of time that the waldrapp ibises spent on inactive behaviour for all categories of the factors gender, age and origin was higher than the norm indicates. A reason for this can be that waldrapp ibises in captivity have less foraging opportunities than their wild conspecifics which spent six to eight ours per day on foraging behaviour (Vargas-Ashby & Pankhurst, 2007). A lot of inactive behaviour increases the chance of leg abnormalities and foot problems such as bumble foot (Vargas-Ashby & Pankhurst, 2007). The time spent on comfort behaviours was influenced by weather condition as well. During rainy weather waldrapp ibises attempt to combat heat loss by covering the legs or tucking the bill into the plumage (Elkins, 1983). Because of this there is not as much room for comfort behaviours as during other weather conditions. However, the statements of Boehm (2006) and Elkins (1983) suggest that this lack of active and comfort behaviour is merely a natural reaction to rainy weather instead of that it indicates a poor coping. This is also emphasized by the fact that the breeding success (a possible consequence of coping) of wild waldrapp ibis populations is better in years with more rainfall (BirdLife International, 2016). This is probably the result of a scarcity of food in dryer periods as less insects are present (Bildstein et al, 1990). For the indicator reproductive behaviour two of the five pairs were homosexual, one male pair and one female pair. Since the waldrapp ibis is a monogamous bird species in which the individuals are pair bonded, a same-sex association may have a significant impact on the bird's reproductive success (MacFarlane et al, 2006). In monogamous bird species homosexual pairs mainly occur in populations with a female-biased sex ratio. In these cases it may be advantageous for two females to co-parent while seeking a reproductive opportunity with a paired male to obtain eggs. (MacFarlane et al, 2006) As there are more adult females present in GaiaZOO than adult males this could be an explanation for the female pair. During the observation period no feather pecking was observed in waldrapp ibises. This means that no clear response to stressful conditions was witnessed (Shepherdson et al, 1998). In addition it means that the educational value of the exhibit is not affected by abnormal behaviour, since the zoo visitors can see behaviour that is adapted to the waldrapp ibises' natural environment (Shepherdson et al, 1998). The indicator enclosure use of the waldrapp ibises was influenced by gender and origin. Of all waldrapp ibises the enclosure use index deviated from the norm, meaning that the available space was not used to its full extent. This can be a result of the fact that the enclosure consists of many different structures and the waldrapp ibises might have developed preferences for specific zones in the enclosure. In the zones which were least occupied by waldrapp ibises few perches and foraging opportunities were present. Thus it can be recommended to offer more perches and foraging opportunities for waldrapp ibises in those zones. For the indicator health, three waldrapp ibises were experiencing health problems. Poor health impoverishes animal welfare as it can limit an animal's ability to cope with challenges in its environment, can restrict behavioural expression and can result in pain (Hosey et al, 2012). Thus, the three waldrapp ibises in GaiaZOO experience reduced welfare, but whether this is due to lack of coping cannot be known for sure.

From the results it appears that female waldrapp ibises cope better with the environment at GaiaZOO than males and that there is no difference in coping ability between young and adult waldrapp ibises. In contrast to the findings of this research Boehm & Bowden (2016) state that older waldrapp ibises (>two years) cope poorly with transfers and new environments, while only juvenile waldrapp ibises have the ability to cope with new structures. The fact that the adult waldrapp ibises at GaiaZOO are able cope with the environment might be due to the good housing and husbandry the waldrapp ibises experience at GaiaZOO. The origin of the waldrapp ibises influences the coping ability as well. The individuals from zoo 1 had the most difficulty in coping with the environment. The fact that some waldrapp ibises are not coping well with the environment reduces the welfare of these birds (Hosey et al, 2012). A failure to cope can lead to a reduction of the birds' fitness, which may be displayed in death, a failure to grow or a failure to reproduce (Broom, 1991). Since it is important to ensure good welfare for the waldrapp ibises and it is important for the EEP of waldrapp ibises that the birds reproduce, it is meaningful to explore what aspects of the factor origin influence the coping ability. Boehm & Bowden (2009) state that when introducing waldrapp ibises, a socially bonded group is considered important. This is in line with this research as the waldrapp ibises of the origin that consisted of the fewest individuals (zoo 1) had the most difficulty in coping with the environment. Another aspect of origin that may influence the coping ability is the difference in housing and husbandry between the origin zoo and the destination zoo. It has to be kept in mind though that the results of zoo 1 are based on two individuals and are therefore not as reliable as the results of the other origins, which consisted of more individuals. However, the differences in coping ability scores for the factor gender were so small that it cannot be concluded with certainty that some individuals were more successful in coping with the environment than others. Added to that there was overlap in the factors gender, age and origin as all origins consist of individuals of only one gender and/or one age class. This makes it harder to decide which are the influencing factors.

The main question of this research was: "How do the waldrapp ibises at GaiaZOO cope with their environment and which factors influence their coping ability?" An answer to this question can now be provided. This research shows that most waldrapp ibises at GaiaZOO were able to cope with the environment, as only the individuals from zoo 1 had difficulty in coping. In addition, the research shows that the factor gender as well as certain aspects of the factor origin influence the coping ability of waldrapp ibises. As discussed above the aspects of origin that influence the coping ability can include the social bonding of a group of waldrapp ibises and/or the difference between the housing of the origin zoo and the destination zoo. For the EEP of waldrapp ibises it means that, when decisions about transfers are made, a minimum number of waldrapp ibises from a zoo should be transferred together. The results from this research indicate that two individuals are too few, whereas five individuals should be enough. Thus, it can be recommended for future introductions to receive at least five individuals from another zoo, although three or four might be enough as well. Furthermore, even though the results of this research do not support it, other investigations (Boehm & Bowden, 2016) indicate that waldrapp ibises above the age of two have difficulty in coping with the environment. Thus, this should be taken into account as well when decisions are made about transferring waldrapp ibises for EEP purposes. In addition, it can be preferred to transfer female waldrapp ibises as they are better able to cope with the new environment. Males do however have the ability to cope with the environment. When these three aspects (social bonding, age and gender) are taken into account, it can improve the coping ability of the waldrapp ibises in the EAZA collection. In addition, it can be recommended to look into the housing and husbandry of the origin zoo in comparison with the destination zoo in order to investigate whether the difference in housing and husbandry might be an issue.

This information can now be used by the EEP coordinator and the Species Committee as it should help them determine the future management of the waldrapp ibis.

5 RECOMMENDATIONS

- To offer more perches and foraging opportunities for the waldrapp ibises in the Taiga I Volière in GaiaZOO in the zones 8, 9 and 10.
- When transferring waldrapp ibises for EEP purposes at least five individuals should get transferred together to the new zoo.
- Only individuals younger than two years should get transferred to a new zoo.
- When possible it can be preferred to introduce female waldrapp ibises instead of male waldrapp ibises.
- Look into the housing and husbandry of the origin zoo in comparison with the destination zoo.
- Follow up with the EEP Coordinator to discuss the results and the potential future management of the waldrapp ibis in EAZA.

LITERATURE

Anderson, M.J. & Robinson, P.A. (2012). *Preliminary evidence of behavioral lateralization in the Northern Bald Ibis Geronticus eremita*. Avian Ecol. Behav. 21: 3–12.

Bildstein, K.L., Post, W., Johnston, J. & Frederick, P. (1990). *Freshwater wetlands, rainfall, and the breeding ecology of White ibises in Coastal South Carolina*. The Wilson Bulletin, 120, 84-98.

BirdLife International. (2016). *Geronticus eremita*. The IUCN Red List of Threatened Species 2016: e.T22697488A93616442. Found on 23 February 2017, at http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22697488A93616442.en

Boehm, C. (2006). *Husbandry guidelines for the Northern Bald Ibis (Geronticus eremita)*.

Boehm, C. & Bowden, C.G.R. (2009). *Northern Bald Ibis Conservation and Reintroduction workshop.* RSPB.

Boehm, C. & Bowden, C.G.R. (2016). *Northern Bald Ibis Conservation and Reintroduction workshop.* RSPB.

Bowden, C.G.R. (2015). *International Single Species Action Plan for the Conservation of the Northern Bald Ibis (Geronticus eremita).* AEWA Technical Series No. 55. Bonn, Germany.

Bowden, C.G.R., Smith, K.W., El Bekkay, M., Oubrou, W., Aghnaj, A. & Jimenez-Armesto, M. (2008). *Contribution of research to conservation action for the Northern Bald Ibis (Geronticus eremita) in Morocco*. Bird Conservation International, 18: S74-S90.

Broom, D.M. (1983). *Stereotypies as animal welfare indicators*. Current Topics in Veterinary Medicine and Animal Sciences, 23, 81-87.

Broom, D.M. (1986). *Indicators of poor welfare*. British Veterinary Journal, 142(6): 524-526.

Broom, D.M. (1988). *The scientific assessment of animal welfare*. Applied Animal Behaviour Science, 20, 5-19.

Broom, D.M. (1991). *Animal welfare: concepts and measurement*. Journal of Animal Science, 69: 4167-4175.

Broom, D.M. & Johnson, K.G. (1993). *Stress and animal welfare.* Kluwer Academic Publishers.

Downes, K. (2012). *Is there a visitor effect on behaviour and enclosure use of mixed bird species in a zoo enclosure?* The Plymouth Student Scientist, 5: 38-60.

EAZA. (2017[a]). *TAGs and breeding programmes.* Found on 23 February 2017, at http://www.eaza.net/conservation/programmes/

EAZA. (2017[b]). *EAZA Breeding programme overview*. Found on 6 March 2017, at http://www.eaza.net/assets/Uploads/CCC/Overview-EAZA-Breeding-Programme-January-2017.pdf

Elkins, C. (1983) *Weather and Bird Behaviour*. T. & A.D. Poyser.

GaiaZOO. (2017). *BioBlitz activiteiten*. Found on 4 April 2017, at https://www.gaiazoo.nl/bezoekers/plan-je-bezoek/evenementen-en-activiteiten/bioblitz-10-06-17/

Grindlinger, H.M. (1991). *Compulsive feather picking in birds*. Archives of General Psychiatry, 48: 857.

Hosey, G., Melfi, V. & Pankhurst, S. (2012). *Zoo animals: behavior, management, and welfare*. Oxford university press.

IAGNBI. (2017[a]). *Northern bald ibis: breeding*. Found on 13 May 2017, at http://www.iagnbi.org/en/breeding

IAGNBI. (2017[b]). *Northern bald ibis: behaviour*. Found on 13 May 2017, at http://www.iagnbi.org/en/behaviour

KNMI. (2017). *Waarnemingen*. Found on 4 April 2017, at http://www.knmi.nl/nederland-nu/weer/waarnemingen

MacFarlane, G.R., Blomberg, S.P., Kaplan, G. & Rogers, L.J. (2006). *Same-sex sexual behaviour in birds: expression is related to social mating system and state of development at hatching*. Behavioral Ecology, 18, 21-33.

Martin, P. & Bateson, P. (2007). *Measuring behaviour: An introductory guide*. Cambridge University Press.

Mason, G.J. (1991). *Stereotypic behaviour categories: a critical review*. Animal Behaviour 41,1015-1037.

Mills, D.S. & Marchant-Forde, J. (2010). *The encyclopedia of applied animal behaviour and welfare*. Cambridge University Press.

Plowman, A.B. (2003). *A note on the Spread of participation index allowing for unequal zones.* Applied Animal Behaviour Science, 83: 331-336.

Ross, S.R., Schapiro, S.J., Hau, J. & Lukase, K.E. (2009). *Space use as an indicator of enclosure appropriateness: A novel measure of captive animal welfare*. Applied Animal Behaviour Science, 121: 42-50.

Serra, G., Peske, L., Abdallah, M.S., Al Qaim, G. & Kanani, A. (2009). *Breeding ecology and behaviour of the last wild oriental Northern Bald Ibises (Geronticus eremita) in Syria*. Journal of Ornithology, 2009, 150(4):769-782.

Shepherdson, D.J., Mellen, J.D. & Hutchins, M. (1998). *Second nature: environmental enrichment for captive animals*. Smithsonian institution.

Soler, J.J., Moller, A.P. & Soler, M. (1998). *Nest building, sexual selection and parental investment*. Evolutionary Ecology, 12: 427-441.

Sorato, E. & Kotrschal, K. (2006). *Hormonal and behavioural symmetries between the sexes in the Northern bald ibis*. General and Comparative Endocrinology 146: 265–274.

Vargas-Ashby, H.E. & Pankhurst, S.J. (2007). *Effects of feeding enrichment on the behaviour and welfare of captive Waldrapps (Northern bald ibis)* (Geronticus eremita). Animal Welfare 2007, 16: 369-374.

Walther, B.A. & Clayton, D.H. (2005). *Elaborate ornaments are costly to maintain: evidence for high maintenance handicaps*. Behavioral Ecology, 16: 89-95.

WAZA. (2017). *Northern Bald Ibis*. Found on 11 May 2017, at http://www.waza.org/en/zoo/visit-the-zoo/storks-herons-flamingos-cranes-and-relatives/geronticus-eremita

Wechsler, B. (1995). *Coping and coping strategies: a behavioural view. Applied Animal Behaviour Science, 43: 123-134.*

Yeniyurt, C., Oppel, S., Isfendiyaroglu, S., Özkinaci, G., Erkol, I.L. & Bowden, C.G.R. (2016). *Influence of feeding ecology on breeding success of a semi-wild population of the critically endangered Northern Bald Ibis Geronticus eremita in southern Turkey.* Bird Conservation International, page 1 of 13. © BirdLife International.

Zims (2017). *Medical records Geronticus eremita, GaiaZOO*. Found on 30 June 2017 at https://zims.species360.org/Main.aspx

APPENDICES

APPENDIX I: RANDOM OBSERVATION SCHEME

	1	2	3	4	5	6	7
Ind1	Red CA	Green DC	Red T7	Green B7	Green DC	Red DC	Red JL
Ind2	White EF	Red TC	Red JL	Green BL	Green FD	Green AH	Red TC
Ind3	Red BS	Red DC	Red LA	Green FJ	White EF	Red BS	Green B7

	8	9	10	11	12	13	14
Ind1	Red CA	Green AH	White EF	Red LA	Red BS	Green BL	Green FJ
Ind2	Red LA	Green DC	Green FD	Red T7	Red DC	Green AH	Green B7
Ind3	Red T7	Green FJ	Green BL	Red TC	Red CA	Green FD	Red JL

	15	16	17	18	19	20	21
Ind1	White EF	Red TC	Green B7	Green BL	Red BS	Green FD	Red TC
Ind2	Red BS	Red CA	Green FJ	Red T7	Red DC	Green DC	Red CA
Ind3	Red DC	Green DC	Red JL	Red LA	Green AH	White EF	Red T7

	22	23	24	25	26	27	28
Ind1	Red LA	Green FJ	Green AH	Red DC	Red T7	Green FD	Red JL
Ind2	Red JL	Green BL	White EF	Red LA	Red BS	Green B7	Green FJ
Ind3	Green B7	Green DC	Green FD	Red CA	Red TC	Green BL	Green AH

APPENDIX II: DATA SHEET

Date	Period	Individual	Gender	Age	Origin	Weather condition	Temp. start	Temp. end	Mean temp.
	1								
	2								
	3								
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