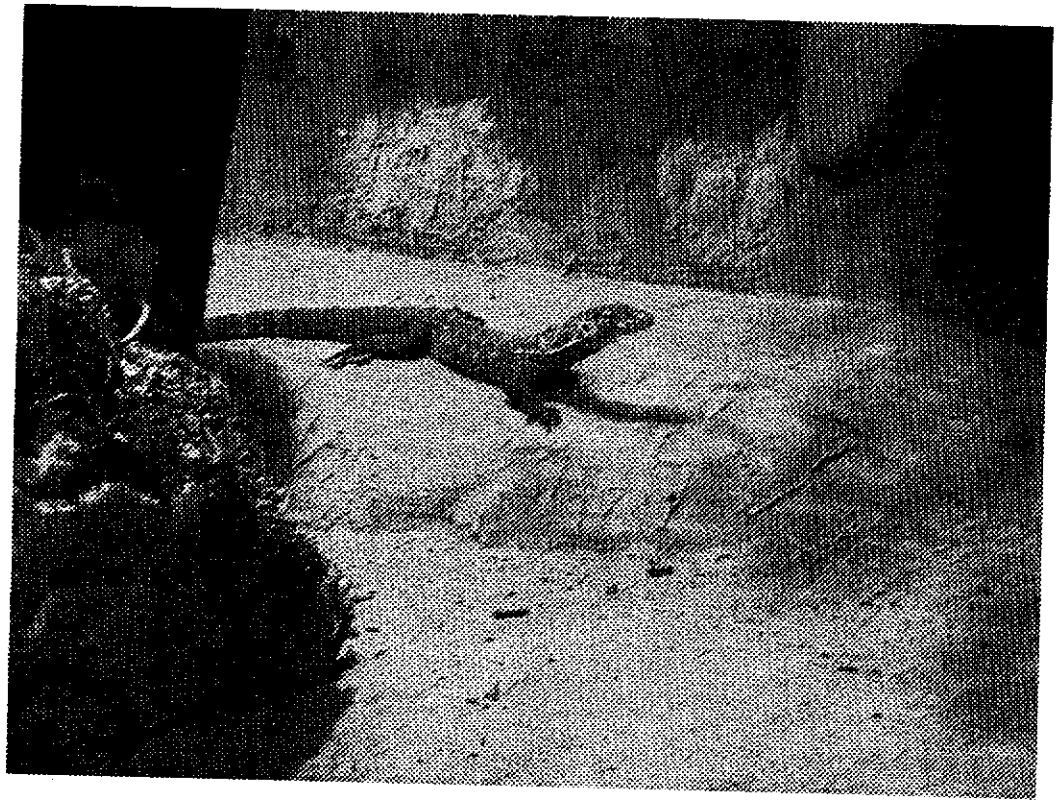
# EXTENDED ESSAY

## BIOLOGY

# Acclimatisation and behaviour of Komodo dragons (*Varanus komodoensis*) in Poznań Zoo



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## ABSTRACT

In November 2005 two jouvenile Komodo dragons (*Varanus komodoensis*) – hatched in captivity – arrived to Poznań Zoo form Gran Canaria. Greatly endangered, these largest living lizards are being breeded at the Zoos to ensure preservation of the species.

This essay presents the four week observations on the two Komodo dragons in order to find whether and how they acclimatize in the new enviroment and what behaviour they display.

The first part of the essay gives some background information about the species, their natural habitat and life in the wild, based on the research and observations performed on wild Komodo dragons. It also presents the description of the Komodo dragon exhibit in Poznań Zoo and, as the aim of the Zoological Gardens is to provide housing conditions as similar to natural as possible, gives the background to the observations of behaviour of the two dragons. The results show the behaviour of Komodo dragons in new environment, their prefered areas of the exhibit, hunting methods and behaviour towards each other as to find the possible dominating individual..

The final section of the essay gives the conclusion of the four week research, stating that the animals have not yet fully acclimatized but both dragons display very different individual behaviour in the new environment. Both lizards, however, show reactions typical to wild jouvenile Komodo dragons, sheltering in the highest possible places. No dominating individual could also be found.

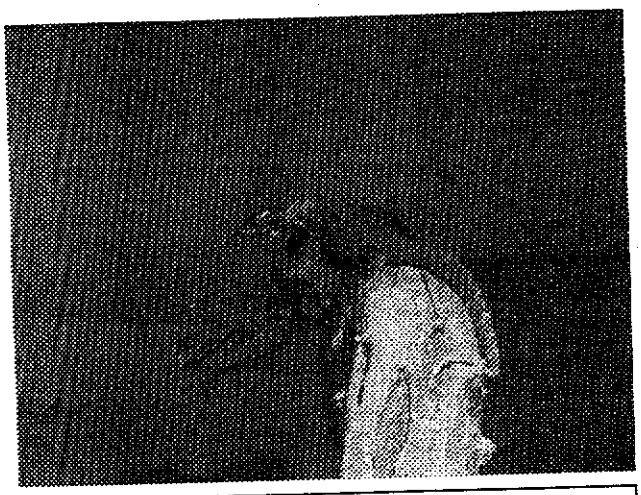
(234 words)

## CONTENTS

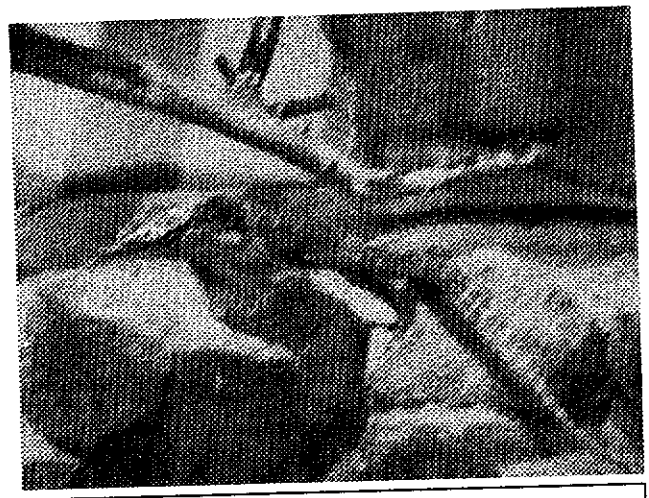
ABSTRACT....2
CONTENTS....3
INTRODUCTION....4
KOMODO DRAGON
Introduction of the species....6
Habitat and life in the wild....7
HABITAT AND LIFE IN CAPTIVITY
Guides for Komodo dragon housing....9
Exhibit in Poznań Zoo....9
Poznań Zoo Husbandry information....12
MATERIALS AND METHODS....13
RESULTS
Settling in the exhibit....14
Reaction to visitors....16
Feeding....16
Activity of the dragons....17
DISCUSSION....19
CONCLUSION....21
ACKNOWLEDGEMENTS....22
REFERENCES....23
APPENDIX 1....24
APPENDIX 2....25

## INTRODUCTION

On 15.11.2005 two Komodo dragons (*Varanus komodoensis*) arrived to Poznań Zoo from Reptilandia Park on Gran Canaria. Both lizards have black and yellow-banded snouts, forked yellow tongues, long necks, brown and grey bodies with orange and yellow spots, black, yellow-specked limbs and yellow-orange tails with gray stripes, the colouring typical for young Komodo dragons. Rinca and Flores are two females that hatched in Reptilandia in November 2004, each now measuring about 1m and weighting approximately 7kg. Rinca is slightly larger and more bulky than Flores, with yellow neck, whereas Flores' neck is earhten red.



**Photograph 1: Rinca**



**Photograph 2: Flores**

The wild population of the Komodo dragon is estimated now to include less than 6000 individuals. The Komodo monitor is listed as CITES Appendix I and as endangered by IUCN[1]. In 1980 the Indonesian islands occupied by these lizards, with exception of the island Flores, were declared the Komodo National Park. About 3500 individuals are considered to live there and another 2000 may live on Flores (3, 4).

In 2004 the overall population of captive Komodo dragons was estimated to be 268 individuals, with 147 kept in Indonesia (4), the homeland of Komodo dragons, which excludes the problem of providing artificial climate conditions for the animals, minimalizing the costs. Keeping a large reptile requires providing a spacious exhibit, and in case of the climate being different to that natural for the animal, providing the required temperature, light and humidity. Poznań Zoo is the first institution in Poland to keep the Komodo dragons. According to the Komodo Dragon European Studbook in 2000 only

[1] International Union for the Conservation of the Nature and Natural Resources

Zoos in Europe had Komodo dragons, from which only one was not in a Western European country[2] 2).

The observations presented in the essay were to reveal whether and how the young Komodo ragons would acclimatize to the new surrounding during the first four weeks of their stay and what ehaviour they would display, in relation with the records of Komodo dragon behaviour in the wild.

[1] A Botanicka Zahrada Plzne, Plzen, Czech Republic

# KOMODO DRAGON

## Introduction of the species

The Komodo dragons, introduced by Peter A. Ouwens in 1912, are the largest existing lizards, belonging to the family *Varanidae* which, according to the estimations of W. Böhme, D. King and P. Baverstock (3) originated in Asia 40 to 25 million years ago. These monitor lizards presently inhabit Africa, South Asia, the Indo-Australian Archipelago, Philippines, New Guinea and Australia (1). They inhabited Australia[3] about 15 million years ago, with the Komodo dragon originating from those lizards and reaching the islands of Lesser Sunda 4 million years ago (3).

Since reptiles, being ectotherms, do not normally need as much energy as mammals of similar size, the Komodo dragon is able to survive eating less frequently than a mammalian top predator. This may explain why these large monitor lizards were able to survive on a small territory of Lesser Sunda islands, with area not exceeding 1000km$^2$ (2). Auffenberg (3), also suggests, that the reason for the dragons to develop such large size may be connected with the previous presence of pygmy elephant (*Stegodon sondaari*) in that area, a prey reaching 1.5m and demanding a large predator. The larger lizards, which were more capable of hunting the elephants, had bigger chances of survival.

Adult male Komodo dragons usually grow up to 3m in lenght, weighting about 90kg[4]. Females reach about 2m and usually weight about 50kg (2, 3). Like all monitor lizards, they have elongated body, however more bulky than smaller species, with narrow head, long neck, well developed limbs and a muscular tail which is slightly laterally compressed[5]. The tail of the jouvenile dragon (up to 4 years old) is proportionally longer than that of the adult, being $^2/_3$ of the whole body lenght while in adults it is ½ of the body lenght. The jouvenile dragons also differ from the adults in colours. The scales of young Komodo dragons are yellow, green, brown, red and gray with specks and bands, while those of adults are usually of one colour, varying from gray to black in different populations, with exeption of the island Flores where the lizards are earthen red with yellow heads (2), however no explanation for this difference in colouring is mentioned in available sources.

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[3] In Australia, up until 25 000 years ago lived a closed relative of the Komodo monitor – *Megalania prisca*. This lizard reached 6m and weighted over 600kg, feeding on large prey and, as the Komodo dragons today, being the top predator. The date of extinction suggests that *Megalania prisca* may have beed encountered by humans. The compctition may be one of the reasons of their extinction.

[4] The biggest Komodo dragon recorded measured 3.13m and weighted 166kg, however such weight has probably been achieved due to undigested food in the lizard's stomach – the Komodo dragons are known to be able to consume up to 80% of their body mass during a single meal, as their stomach can expand very easily.

[5] This helps the lizards to swim – they use the tails to move while keepieng all limbs close against the sides of their bodies – very similar to swimming crocodiles.

Komodo dragons have powerful claws on each digit, their main weapon however, are few rows of large, serrated teeth used to tear apart the victim[6]. The saliva of wild Komodo monitor contains over 50 different strains of bacteria, at least 7 of which are highly septic (3). Therefore, event if a bitten victim managed to escape, the infection caused by the bacteria in the wound will cause its death[7] (5).

Komodo dragons are able to see objects – preferably moving – that are even 300m away. Their retinas have only cones, so the dragons do not see well in dim light. They are only able to hear a small range of sounds, probably between 400 and 2000Hz[8]. The sense of smell is the primary tool for the Komodo dragon when locating food and mates: the long, deeply forked tongue picks up chemical cues in the air and the Jacobson's organs located on the roof of the mouth recognize the molecules and depending on their concentration on each tip of the tongue, the dragon is able to tell the direction from which the smell is coming (3) even from as far as 10km (4).

## Habitat and life in the wild

The wild Komodo dragons live presently on 3 islands of Lesser Sunda in Indonesia (Appendix 1): Komodo, Rinca and the western part of Flores, with temporary small groups present on smaller islands nearby: Padar and Gili Motang[9] (4).

Komodo dragons inhabit mainly the lowland monsoon forests and savanna of these volcanic islands. The climate is xeric with temperature varying from 43°C to 17°C throughout the year (2).

They are solitary and territorial lizards with their territories divided into 'core areas', which they defend, and 'foraging areas'. In the core areas the animals spend most of their time and they try to avoid each other there (4). The foraging areas of different individuals can overlap and are generally much larger, being the area where the lizard wanders out in search for food and mates.

The large adults hunt large prey, such as Sunda deer (*Cervus timorensis*), wild boar (*Sus scrofa*) or wild buffalo (*Bubalus bubalis*)[10] (5). The dragons also feed on carrion, which may be the reason for the presence of the bacteria in their saliva (2). As captive dragons do not eat carrion, their saliva does not

[6] The jaws of a Komodo dragon are similar to those of a shark, with new teeth replacing the old ones through out their whole life.
[7] The bacteria do not affect the lizards themselves – after various fights even in severely wounded monitors there was no blood poisoning. This sugested that the dragons have natural immunity to the infection and later a powerful antibacterial agent in blood plasma was found.
[8] Their ear contains only a single bone and cochlea has fewer receptor cells than in mammalian ear.
[9] The fact that these islands are repopulated and depopulated by these groups prooves that the Komodo monitors swim from one island to another, therefore are able to survive some time in sea water.
[10] All of which are not native to the Lesser Sunda islands, but they, alongside with megapode birds, have replaced the pygmy elephants therefore enabeling the dragons to survive.

contain the deadly bacteria. Adult Komodo dragons usually use ambush when hunting large prey, suddenly attacking and bringing it down to the ground to rip it apart – often together with other dragons entinced by the smell. When dealing with smaller prey, such as snakes or small mammals, Komodo monitors usually hunt actively, even chasing the animal (5).

Between May and August, mating between the Komodo dragons takes place (3). The female lays between 30 and 50 eggs (1) in September, usually in burrows on hill slopes or the nests of bush turkeys (*Megapodius reinwardt*). The incubation takes about 9 months, during which the female may lay on the eggs. After the haching however, there are no indications of parental care (2, 3).

Jouvenile Komodo dragons are arboreal, their small size enabling them to climb trees and therefore escape adult Komodo monitors which would otherwise eat the young. To hide, young lizards also mask their natural scent by rolling in feaces, which the adults remove from the interstines of the prey before consumption. While spending their first 4 years in the trees, young dragons feed on insects, small reptiles, birds and mammals, until they reach 2m lenght and weight about 25kg (at approximate age of 5) when they become too heavy to stay up on the trees move to larger prey, such as monkeys, goats, wild boars and deer (3). They are able then to compete with other dragons.

## HABITAT AND LIFE IN CAPTIVITY

### Guides for Komodo dragon housing

According to *Komodo Dragon Husbandry Manual of the AZA/SSP EAZA/EEP* (4), captive Komodo dragons should be kept in spacious facilities with the biggest possible resemblance to their natural enviroment, preferably with separate basking and nesting areas, pools and plants serving as visual barriers. If the climate does not allow an outdoor exhibit to provide direct sunlight, a greenhouse exhibit or artificial UV light should be put instead, to ensure animal's access to sunlight. The climate of the exhibit should be established by low humidity and temperature range between 25° - 45°C. Proper furnishing, including climbing facilities for jouvenile lizards and ground composed of soil or sand that would enable burrowing should be provided, as well as access to drinking water.

The feeding of the Komodo dragons depends on their age and size, with hatchlings fed mice every few days, later to be introduced to larger meals once a week, adults receiving 1.5 – 3kg of food per week.

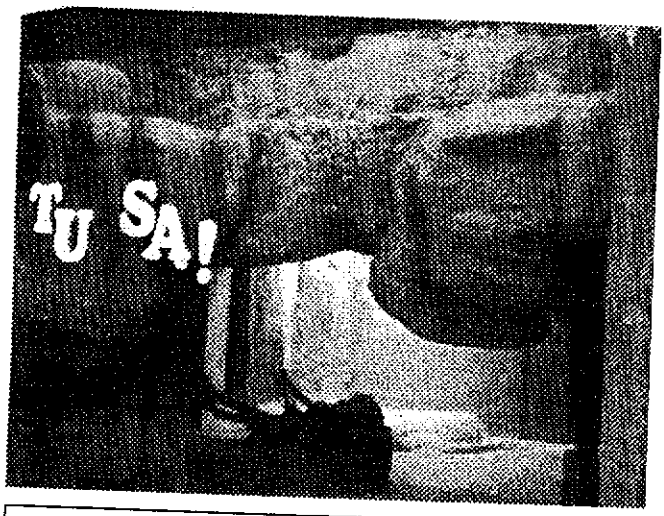
Due to their solitary lifestyle, adult Komodo dragons are often kept singulary or in pairs in North American Zoos, whereas Indonesian Zoos keep adults in groups of similar size. Jouvenile siblings are usually kept together.

### Exhibit in Poznań Zoo

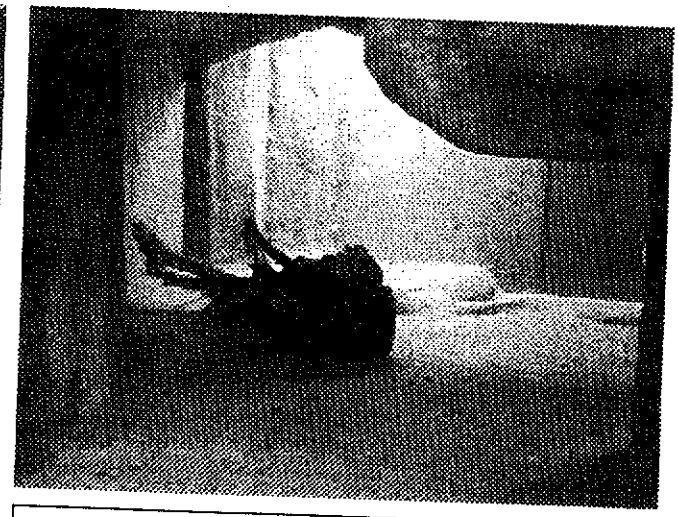
Due to the outdoor temperate climate, the Komodo dragon exhibit in Poznań Zoo is entirely indoors, located in a separate building. It is divided into two chambers: left (3x4x3m) and right (5x4x3m) with a joining door (1x1.2m). The audience is able to see the animals from outside thanks to 3 exhibition windows (Photograph 3) that also, alongside with a window in the ceiling, enable natural sunlight to reach the lizards (Figure 1). The ground is covered with sand.

**Photograph 3: The building of the Komodo dragon exhibit in Poznań Zoo**

The left chamber is partly divided creating a front and back niche, the front containing a high shelf with recesses for plants (Photograph 4) and the back partly occupied by a small hill on which a half of a hollowed trunk is put (Photograph 5). Above it, there is a lamp, and a wire-netting covered lamp with the heater is also installed on the wall just above the exhibition window. There are entering door in the back wall of the chamber (Figure 1).




**Photograph 4: High shelf in the front niche of the left chamber of the exhibit**



**Photograph 5: The back niche of the left chamber of the exhibit**

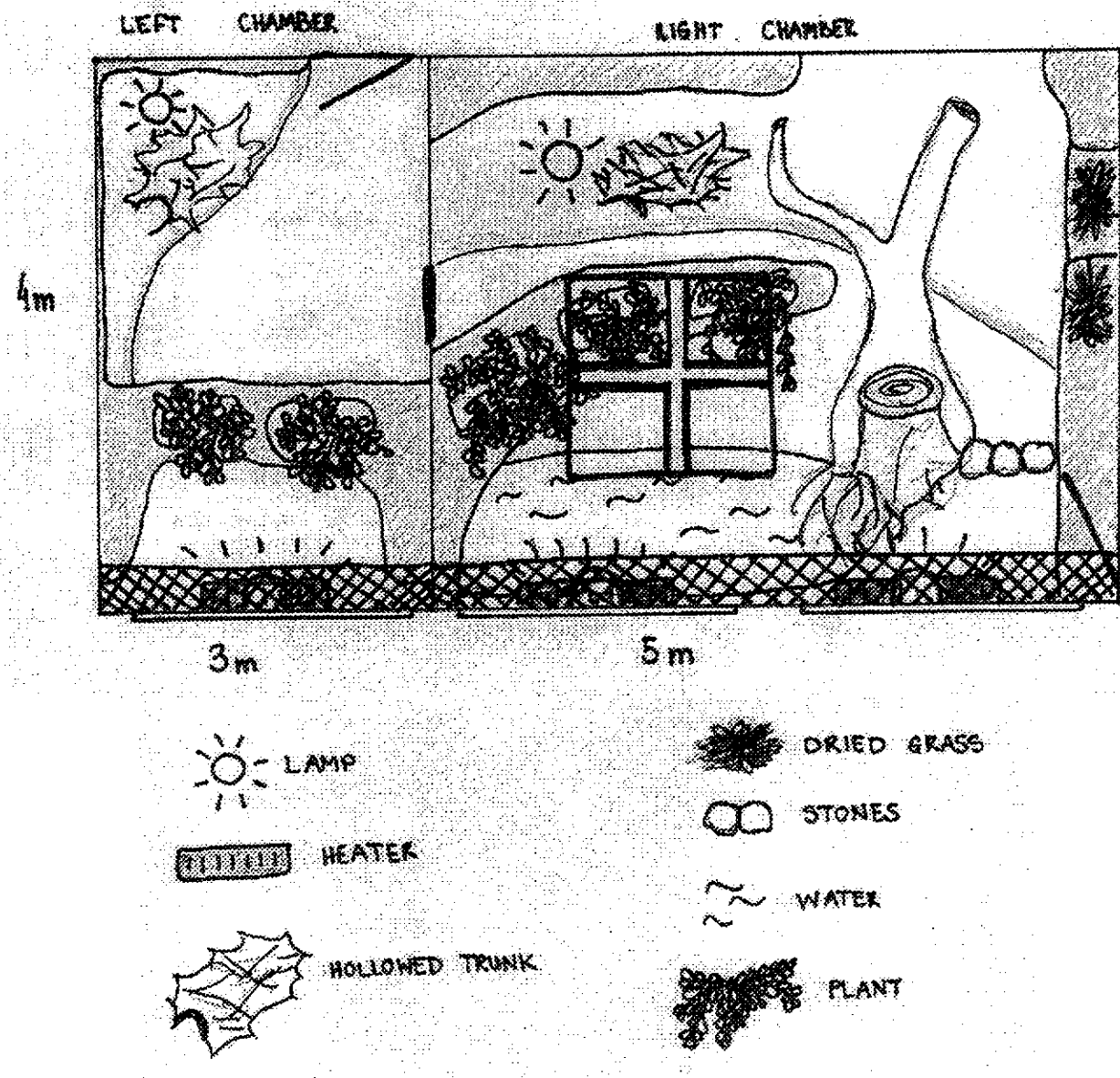



**Figure 1: The scheme of the Komodo Dragon exhibit as seen from above.**

The temperature of the exhibit ranges from 24°C on the ground to over 40°C right under the ceiling, where the heaters are installed.

### Poznań Zoo Husbandry information

Each Komodo dragons is offered few (usually 3) whole mice twice a week.

## MATERIALS AND METHODS

I held my observations of the Komodo dragons daily for four weeks (16.11.2005 – 13.12.2005) starting from the first day after their arrival, at various hours – mornings and afternoons – and for different periods of time, lasting from 20 minutes to 2 hours, depending on their activity and my timetable. There were 28 periods of observetion lasting in total 18h 40min. This time however is not enough to make certain and significant conclusions, as a preferably constant observation from the moment of their arrival would provide more data of the lizards' initial behaviour in the new surrounding.

I made detailed notes of their positions and behaviour (Appendix 2), focusing on their relative position towards each other, responses to the outside environment, activity and behaviour they displayed. I observed the dragons from outside, as due to safety reasons only the previously trained keepers can enter the exhibit. All the photos and films I took were also taken from outside, no flash was used to avoid scaring the animals.

When standing close to the window, I tried to move as little as possible, to avoid being noticed by the dragons and thus interfere in their surrorunding influencing on their behaviour.

During the period the observations took place, some facilities, including new trunks and branches and a new heater were added to the exhibit. I recorded the reactions of the Komodo dragons to them. During the time of the observation I also witnessed feedings on the $10^{th}$ and $24^{th}$ day.

# RESULTS

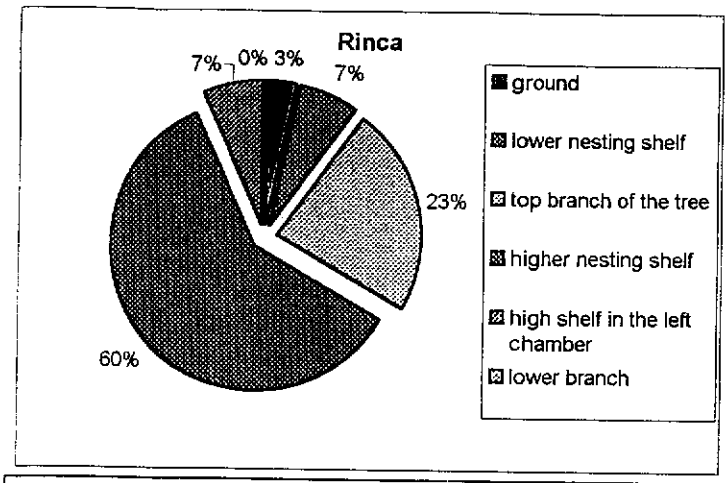
## Settling in the exhibit

After the first day from their arrival, during which the Komodo dragons were closed in the left chamber, the lizards started to settle in new areas of the exhibit, where they spent most of their time. Table 1 presents the days in which I saw each dragon start occupying a new place in the exhibit.

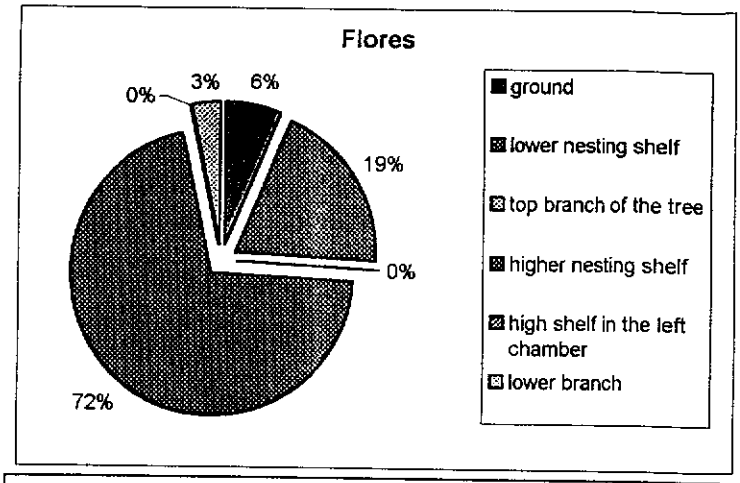
| Area | Rinca | Flores |
|---|---|---|
| Left chamber of the exhibit | 1st day | 1st day |
| Trunk | 1st day | 1st day |
| High shelf | 9th day | – |
| Right chamber of the exhibit | 2nd day | 2nd day |
| Higher branch of the withered tree | 2nd day | – |
| Lower branch of the withered tree | – | 2nd day |
| Nesting area | 11th day | 3rd day |
| Higher shelf the nesting area | 11th day | 3rd day |
| Lower shelf of the nesting area | 24th day | 16th day |
| Basking area | – | 28th day |
| Protruded shelf | – | 28th day |

**Table 1: The days from the arrival in which each lizard was seen occupying the new area of the exhibit.**

Both lizards showed preference to higher areas of the exhibit. Rinca spent 97% of the observation time (Graph 1 – green coloured) either on a high branch or shelf, at least 180cm above the ground. Flores spent a little more time lower – being on the ground twice and spending the second day on the lower branch of the withered tree, but 91% of the time (Graph 2 – green coloured) she was either on the higher or lower nesting shelf, always over 170cm above the ground.




**Graph 1: Percentage of the observation time spent by Rinca in differnt areas of the exhibit**




**Graph 2: Percentage of the observation time spent by Flores in different areas of the exhibit**

As graphs 1 and 2 show, the dragons had their favourite places in the exhibit – the most favourite was the high nesting shelf where both Flores and Rinca spent over half of the total time. Flores ocuupied it alone from 3rd to 11th day and to 15th day with Rinca. On the 16th and 17th day Rinca was alone on the higher shelf while Flores moved to the lower one but from the 18th day onwards they were together on the higher shelf again, with Flores only leaving it on 22nd and 28th. A lot of time – from the 2nd to 9th day – Rinca spent on the top branch of the withered tree. She was there alone and Flores was visible on the lower branch on the 2nd day, before she moved to the higher nesting shelf. This was the sigh of rivality for the best place, which showed Rinca dominant – she did not let Flores onto her branch but on the 11th day moved onto her shelf.

The Komodo dragons spent 15 out of 28 days staying together in the same place: during the 1st day, when they were locked in the left chamber of the exhibit both hiding under the trunk and later, since the 11th day, when Rinca joined Flores on the higher shelf in the nesting area.

When the furnishing in the exhibit changed and new elements were added, the reaction of the Komodo dragons was sometimes to change their favourite places (Table 2).

| Day after arrival | New Element | Rinca | Flores |
|---|---|---|---|
| 2nd day | The joining door were open | Moved to the right chamber of the exhibit | Moved to the right chamber of the exhibit |
| 6th day | Two pieces of a tree trunk were added to the basking area in the right chamber | No reaction | No reaction |
| 9th day | Big climbing branch was added to the right chamber, settled right next to the withered tree but enabling easier access to the nesting area | Moved to the high shelf of the left chamber | No reaction |
| 28th day | A new heater was installed just above the high branch of the withred tree | No reaction | Walked around the exhibt |

**Table 2: Reactions of Rinca and Flores to new elements of the exhibit.**

## Reaction to visitors

Since the 1st day after their arrival, Rinca and Flores were exposed to the visitors whom they were also able to see through the exhibition windows. This would enable them to get used to the audience. Throughout my observations they usually did not pay attention to one person standig by the window and were not afraid. On the 1st and 28th day Flores even approached the window and flicked her tongue over where I was standing. When two or more people stood by the window, moving a lot or making noise, the Komodo dragons were alarmed, lifting up their heads and observing intensively. This happened especially in Rinca's case between 2nd and 8th day, when she was on the top branch of the tree, clearly visible for the audience. On the 9th and 10th day when she was on the high shelf in the left chamber, she tried to hide as high as possible each time someone approached the window. While staying on the shelf, she was close to the exhibition window and the movement outside. As both dragons were on the high shelves in the nesting area, they did not look alarmed as long as there were no loud noises or a group of people moving.

## Feeding

During the feeding time, when the lizards occupied separate spots (during the 10th day), each dragon was usually thrown 3 alive white mice, ofwhich one was first offered to Rinca on clippers, but she run away from it. The dragons chased the thrown mice (not flicking their tongues) and caught in their mouth, making one or two quick bites, titled their head up and swallowed, all this lasting about 3 minutes.

As during the feeding on 24th day both dragons were on the higher shelf of the nesting area, when thrown more mice, they once both grabbed the same mouse and were struggling over it for about 6 seconds, finally tearing it apart. Since Rinca was the first to catch this mouse, she got the bigger piece. Flores however, did not let the mouse go.

There was no definite time of feeding during the time of the observations and the lizards were fed twice a week at random hours, depending on how hungry they were (keeper, pers. comm.).

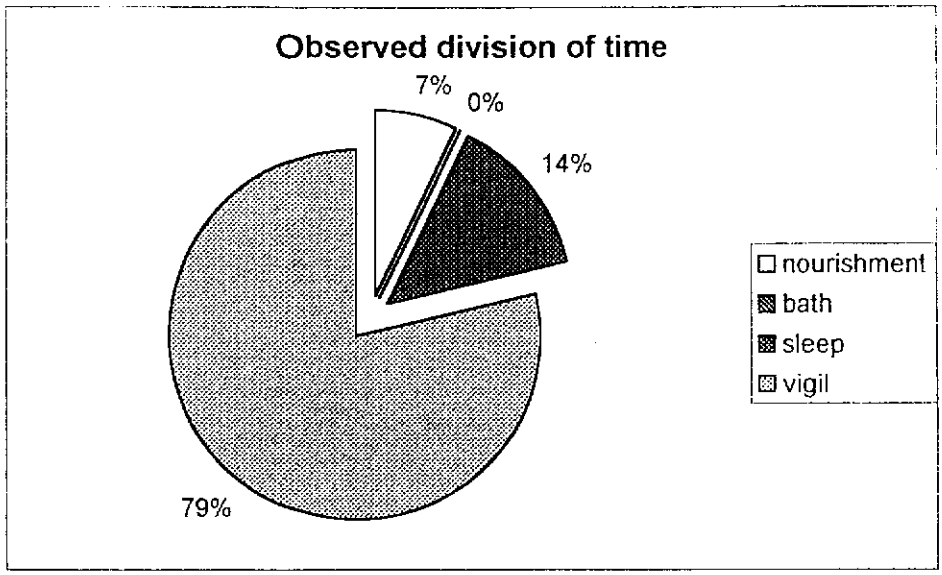
**Activity of the dragons**

| Time of the observation | Rinca | Flores |
|---|---|---|
| 1st day afternoon | resting | active |
| 2nd day afternoon | resting | resting |
| 3rd day afternoon | resting | resting |
| 4th day afternoon | resting | resting |
| 5th day afternoon | resting | resting |
| 6th day afternoon | resting | resting |
| 7th day afternoon | resting | resting |
| 8th day morning | resting | resting |
| 9th day afternoon | active | resting |
| 10th day morning | active | active |
| 11th day afternoon | resting | resting |
| 12th day afternoon | resting | resting |
| 13th day afternoon | resting | resting |
| 14th day afternoon | resting | resting |
| 15th day morning | resting | resting |
| 16th day afternoon | resting | resting |
| 17th day morning | resting | active |
| 18th day morning | resting | active |
| 19th day afternoon | resting | active |
| 20th day morning | resting | resting |
| 21st day afternoon | resting | resting |
| 22nd day morning | resting | resting |
| 23rd day afternoon | resting | resting |
| 24th day afternoon | active | active |
| 25th day morning | resting | resting |
| 26th day afternoon | resting | resting |
| 27th day morning | active | active |
| 28th day afternoon | resting | active |

**Table 3: Activity of the Komodo dragons in the mornings and afternoons.**

There were no certain rythms of the day and Flores and Rinca were both active or resting in the morning as well as in the afternoons (Table 3). While resting, most of the time they spent with their eyes open

(Graph 3), either with their heads up, observing the surrorunding or laying down. During that time, sometimes Rinca closed her eyes for apprximately 5 second and then opened them again. Both only slept 4 times during my observations: Flores on 6th, 9th, 11th and 25th day, Rinca on 11th, 16th, 25th and 28th day.




**Graph 3: The percentage of time observed, spent on different activities by the Komodo dragons**

## DISCUSSION

Climbing is the innate behaviour displayed by the jouvenile Komodo dragons. When staying up in the trees, they cannot be reached by the adults and therefore are able to survive (3). Only as they grow and become too heavy to stay up in the trees, they start to spend their time on the ground. Both Rinca and Flores tried to find shelter in the highest possible spot, thus gaining a good viewing point and protection from potential predators, which in nature would be adult Komodo dragons.

As the two trunks added on the 6$^{th}$ day did not influence the lizards' position or behaviour, but the addition of a new branch disturbed Rinca and probably caused her to leave the top branch and move to the left chamber, where she tried to hide on the front shelf. That sudden change of the surrorunding has probably also caused her to run away from the mouse offered on the clippers on the 10$^{th}$ day, as during the previous feeding she has been catching the mouse straight from the clippers (keeper, pers. comm.).
In the wild, Komodo dragons are solitary animals (2). When exposed to both chambers, untill the 11$^{th}$ day they chose different spots to stay in, always high. From the 11$^{th}$ day onwards, Rinca and Flores stayed on the nesting shelf together. This may be just the result of their preference and the fact they felt safer in that area, as captive Komodo dragons, especially young siblings, are usually kept together (2).

Only Flores was spotted coming down from the shelf, at first only when no one was around (keeper, pers. comm.) and the signs on the sand indicated her movement. On the 28$^{th}$ day, however, she walked around the chamber in my presence, which showed she was now much more familiar with the exhibit. Both dragons showed signs of being alarmed when there was noise or movement or people outside the exhibit. However, while staying on the higher shelf they seemed to be rather calm only observing the commotion. On the other hand, they tried to escape when being more exposed as Rinca on the high shelf in the left chamber (9$^{th}$ day). It may be the indication of both, their uneasiness in the new environment and the natural instinct of young dragons, climbing as high as possible to escape potential danger.

Another reason both dragons remained in higher area most of the time is the fact, air temperature there was close to 40°C whereas only 24°C on the ground – the temperature variation similar to that in the wild (2). As ectotherms, lizards cannot produce heat and are fully dependent on the temperature of their surrorunding. The lower the temperature, the less active the lizard is (5). As the temperature outside the exhibit was around 0°C most of the time, the temperature at the bottom of the exhibit, especially close to the exhibiton windows, may have been too low for the dragons. The reason for Flores to be so active on the 28$^{th}$ day may have also been the slight raise of the temperature of the exhibit, caused by the installation of the new heater. The change of the climate and temperature after transfering from Gran

Canaria to Poland could also have some impact on the animals' remaining motionless. No precise information about the conditions in Reptilandia are avaliable though.

There is no direct proof for domination of either of the females, however, the size of Rinca and her initial aquisition of the top branch and later transfer to the shelf occupied by Flores, could indicate her higher position. However, the fact that Flores did not let go when struggling for the mouse contradicts with the dominating position of Rinca. In nature, adult males usually become the dominating individuals and also tend to be more territorial (4), therefore there may not be a dominant female among the Komodo dragons in the Zoo.

When hunting for mice both dragons actively chased them individually, which is a behaviour typical for most varanids, including young Komodo dragons, whereas adults use a secondarily evolved ambush tactic (5), though usually to catch a bigger prey. However, Rinca ald Flores displayed behaviour observed typically on adult Komodo dragons when ripping the mouse apart between each other (3).

There was no relationship between the time of the observations – mornings or afternoons – and the activity of the lizards. In nature, Komodo dragons usually bask in the early morning, then search for food, retreat to shade in the hottest hours of the day, search for food in the late afternoon and then retire for the night (6). Neither Flores nor Rinca behaved so, however that may be caused by the fact captive dragons are provided with food, as well as the artificial light in the exhibit and no strong sunlight in November and December.

## CONCLUSION

After four weeks the Komodo dragons became familiar with the new surroundings, however, since new facilities are added to the exhibit all the time, it cannot be stated the lizards have already fully acclimatized. Each lizard, reacted differently to the new elements and Rinca changed her place when the new branch was added. Though Flores did not react to that. None of them also reacted to adding two new trunks, but after installing the heater Flores became much more active.

Flores was also less afraid of humans, since she did approached the window and walked around the exhibit, whereas Rinca tried to hide when people were around. Both dragons, however, are alarmed by intense noise and movement of more than one person outside the exhibit.

No dominance of either of the lizards was visible, but probably due to greater size, Rinca occupied the higher branch.

The Komodo dragons hatched in captivity display behaviour observed on wild jouvenile Komodo dragons, they prove to be arboreal with hunting techniques including active chasing of the prey. When running, Komodo dragons do not flick their tongues. Both females showed solitary preference at first but later proved to be able to share their core area, which showed they felt safer on the higher shelf. This proves the innate behaviour of jouvenile Komodo dragons hiding in the trees, as was observed in the wild (3).

## ACKNOWLEDGEMENTS

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## APPENDIX 1

### Range of habitat of Komodo dragons in the wild (Indonesia)

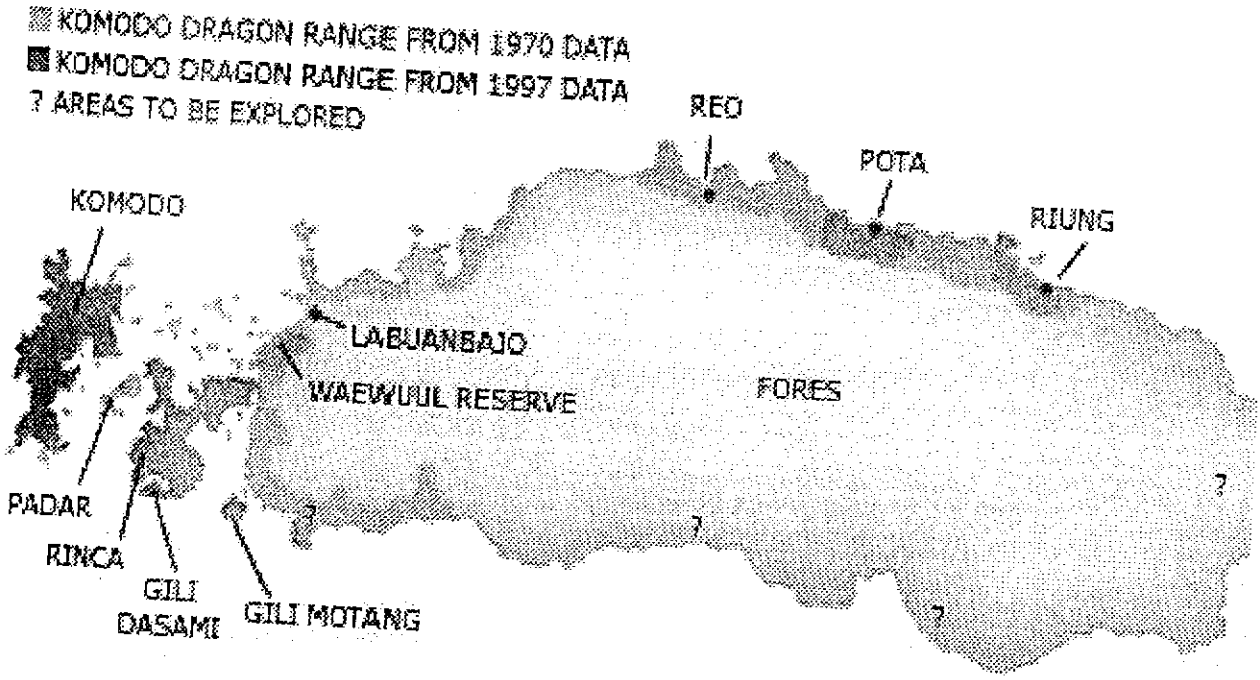


**Figure 2: Map of the Lesser Sunda islands where Komodo dragons live (7)**

## APPENDIX 2

### Record of the observations

**1st day after arrival**

**1h 15min (12.15-13.30)**

Both Rinca and Flores were kept in the left chamber of the exhibit with the joining door closed. At first, Rinca was visible sitting on the trunk in the basking area, later to be joined by Flores and both sat there together for 15 minutes. After that Flores got off the trunk and started wandering around the exhibit, first walking towards the entering door and than heading off to me. She flicked her tongue over the glass of the exhibition window and circled the exhibit twice, all the way flicking her tongue and leaving a trace on the sand with her tail. Then she hid under the trunk and so left it again, she moved around close to the wall and hid under the trunk again. After 5 minutes Rinca turned on the trunk and hid under it together with Flores. The movements under the trunk were visible and after 15 minutes Flores came out again and settled behind the trunk but after 3 minutes hid under it again. When Flores was walking, she flicked her tongue the entire time.

The left side of the trunk was covered in dried blood, probably from a meal they received there or put there to encourage them to hide there.

**2nd day**

**30min (12.15-12.45)**

The joining door were open and both Flores and Rinca settled in the right chamber of the exhibit, Rinca positioned on the top branch of the withered tree (Photo 1) while Flores occupied the lower branch. Rinca moved her head a little but both were lying on the branches, closing their eyes.

**Photo 1: Rinca on the withered tree in the right chamber (2nd day)**

**3rd day**

**30min (14.20-14.50)**

Rinca was positioned on the same high branch, however, Flores moved to a higher area on the high nesting shelf, lying close to the heater above the exhibition window. Rinca jerked her head up each time someone approached the exhibiton window.

**4th day – 5th day**

**20min (13.00-13.20)**

**20min (14.00-14.20)**

Both Rinca and Flores remained in the same places, on the top branch and the high nesting shelf, jerking their heads up when alarmed by people moving outside and talking, and moving a little within these spots but generally remained motionless. When no people were moving on the outside of the exhibit, Rinca closed her eyes for approximately 5 seconds, then opened them and later closed again. Flores slept.

**6th day**

**50min (9.00-9.50)**

Two new pieces of a tree trunk appeared at the basking area in the right chamber. Both dragons did not change their spots, Rinca lying on the high branch and Flores on the shelf.

**7th day – 8th day**

**20min (13.10-13.30)**

**35min (8.30-9.05)**

The dragons still remained in the same places, Flores only shifting her position on the shelf but staying close to the heater. Both held their heads up and observed the surroundings.

**9th day**

**25min (14.15-14.40)**

A new climbing branch was added to the right chamber, positioned in between the withered tree and the right wall with the nesting shelves, possibly giving a better access to that area. Flores remained in her position, sleeping on the higher nesting shelf, while Rinca moved to the left chamber of the exhibit and climbed onto the front shelf with plant recesses. When I approached she climbed onto the right ledge of the shelf so that only her tail was left visible.

**10th day**

**35min (8.30-9.05)**

***Before the feeding***

Flores was sitting on the nesting shelf in the right chamber of the exhibit with head titled up. Rinca was sitting on the left part of the shelf in the left chamber of the exhibit with head titled up, observing.

*Feeding*

Three white mice were thrown one after the other on the shelf where Flores sat, she ran after each one and caught it in her mouth, making one or two quick bites and titled her head up to swallow. To Rinca, the first mouse was offered using long pincers but she ran away from it to hide behind the plants when the pincers came close to her, then the mouse was thrown onto her shelf and after spotting it she qickly approached. When she swallowed the mouse, two other were thrown onto the shelf, one after the other and Rinca caught each one. While running after the prey, the dragons did not flick their tongues.

*After the feeding*

Flores came closer to the heater and sat there observing. Rinca climbed the left ledge of the shelf and stayed there, head titled up, observing.

**11th day**

**20min (13.00-13.20)**

Both Flores and Rinca lied on the high nesting shelf in the right chamber of the exhibit. Flores settled closer to the heater, sleeping, Rinca slightly behind her, with her head lying on the base of Flores' tail. She opened her eyes for about 5 seconds and closed them again.

**12th day – 15th day**

**30min (12.30-13.00)**

**20min (12.30-12.50)**

**20min (13.30-13.50)**

**50min (9.00-9.50)**

Both dragons stayed on the shelf, Flores closer to the heater and Rinca either on the heap of dried grass (furthest from the heater) or next to it. They were either sleeping or observing the enviroment, but not titling their heads up.

**16th day**

**30min (14.00-14.30)**

Flores moved to the lower nesting shelf (Photo 2), both were lying on the heaps of dried grass, sleeping.

**17th day**

**1h (8.30-9.30)**

Both dragons were in same places as before, however, when the noises from the outside reached them, only Flores jerked her head up and stayed alarmed. When later people came, both Flores and Rinca looked up and started observing.

**Photo 2: Rinca on higher and Flores on lower nesting shelf (17th day)**

**18th day**

**50min (10.00-10.50)**

Flores moved back to the higher shelf, closer to the heater. She held her head up and yawned. Rinca lied closer to the dried grass, sleeping.

**19th – 23rd day**

**25min (13.00-13.25)**

**35min (9.00-9.35)**

**25min (13.15-13.40)**

**40min (9.00-9.40)**

**35min (14.00-14.35)**

Rinca stayed throughout the days on the higher shelf while Flores move from higher to lower shelf. Also signs of digging in the left chamber of the exhibit and fallen grass from the shelves indicate movement of the animals.

**24th day**

**1h 35min (14.00-15.35)**

***Feeding***

At first both dragons were on the lower shelf, watching a mouse that was walking on the sand – fell down when thrown. Then another mouse was thrown in the direction of the upper shelf but fell on the ground, Rinca moved on the upper shelf whele Flores starded to climb down from the shelf to reach the mouse. When a third mouse was thrown on the shelf Rinca ran after it and caught it, while the two mice from the ground were picked up and Flores climbed onto the upper shelf. Another mouse was thrown on the shelf, close to the heater, and right after that another one closer to Rinca, she caught it but Flores also grabbed a piece. They were struggling over the mouse for about 6 seconds, finally teared it apart – Rinca got the

bigger piece – and ate it. Flores ran after the other mouse that landed next to the heater and as Rinca started to do that too, another mouse landed on the base of her tail and run up onto her head. Rinca brushed it of with her forleg and caught it quickly with her snout.

***After the feeding***

Flores moved to the dried grass and nestled there as Rinca walked closer to the heater.

**25th day – 26th day**

**20min (11.30-11.50)**

**25min (13.00-13.25)**

Both lizards lied on the higher shelf near the dried grass, observing.

**27th day**

**1h 20min (9.00-10.20)**

Both dragons settled on the higher shelf, Flores close to the heater and Rinca on the dried grass. After 20 minutes Rinca yawned, then both approached each other, started to flick each others snouts with their tongues, Flores moved to the lower helf and 2 minutes Rinca followed. As people approached the exhibit, both lizards jerked up their heads, Rinca went back to the higher shelf and settled on the grass. When walking bot dragons flicked their tongues.

**28th day**

**2h (13.15-15.15)**

The new heater was instaled, just above the top branch of the withered tree. Rinca lied on the high shelf, on dried grass, sleeping. Flores was in the middle recess of the protruded shelf. She then moved to the left recess, where *Bougainvillea* grew (Photo 3). She climbed the plant and walked on it, then moved further o the shelf and back onto the plant (Photo 4). After 20 minutes, she started digging in the ground the plant grew on, using her forelegs while her hind legs held to the edge of the shelf, her tail hanging down. After digging for 10 minutes, she moved to the right recess of the shelf and after 10 minutes decided to climb dow the plant that was growing there. When she reached the ground, Flores started to wander around the right chamber of the exhibit, lying shortly several times in the basking area (Photo 5) and climbing the tree trunks (Photo 6) and the wall (Photo 7). She approached me twice, checking out the glass with her tongue and not being afraid of my presence (Photo 8). All the time when walking, she flicked her tongue.

Photo 3: Flores walking from the middle to the left recess of the protruded shelf in the right

Photo 4: Flores on Bougenvillea (28th day)

Photo 5: Flores on one of a trunk at the basking area (28th day)

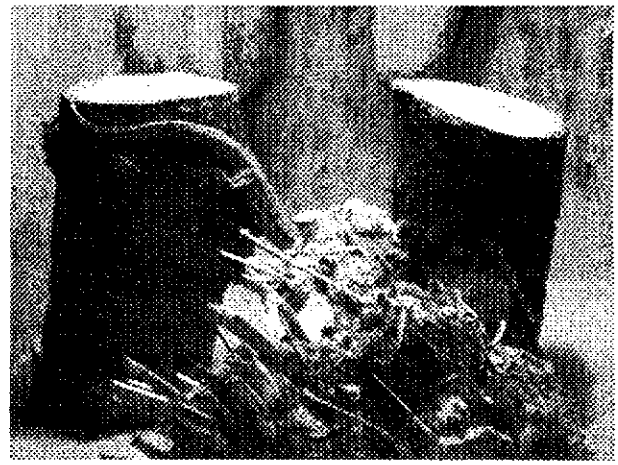

Photo 6: Flores coming off from a trunk at the basking area (28th day)

Photo 8: Flores climbing the wall in the righ chamber of the exhibit (28th day)

Photo 7: Flores approaching the glass window (28th day)