From the Swiss Federal Veterinary Office Berne-Liebefeld (Director: Prof. Dr U. KIHM), the Zoological Garden Basel (Director: Dr P. STUDER), the Municipal Zoo "Dählhölzli" Berne (Director ad interim Dr R. BAUMGARTNER), and the Zoological Garden Zurich (Director: Dr A. RÜBEL)

HUSBANDRY AND PATHOLOGY OF LAND TORTOISES (TESTUDINIDAE) IN SWISS ZOOS

By P. Dollinger, O. Pagan, T. Jermann, R. Baumgartner and R. E. Honegger

Introduction

Keeping land tortoises has a long tradition in Swiss zoos. Basel Zoo purchased its first tortoise, a gopher (Gopherus polyphemus), in 1875, one year after the zoo had opened its gates. As from 1897, the Testudinidae family was represented by the marginated tortoise (Testudo marginata) and, as from 1903, also Testudo hermanni, Geochelone sulcata and G. nigra (= elephantopus)¹ were kept. While the zoo owned only one single animal of certain species (T. marginata, G. pardalis), others were kept in groups (e.g. 23 Testudo hermanni). At that time, most tortoises survived for only one year. In the 1950ies and until 1979, Basel Zoo kept a larger group of giant tortoises (G. nigra and gigantea), and until the 1980ies, some other tropical tortoise species were in the collection (Kinixys belliana, G. denticulata, G. elegans). Today, only two tortoise species are kept (G. pardalis and G. radiata). 11 of the radiated tortoises are animals confiscated by the Swiss Federal Veterinary Office and given to Basel Zoo on a permanent loan basis. A similar development could be observed in Zurich Zoo, where, in 1929, a group of Galapagos giant tortoises (G. nigra) was praised as one of the major attractions of the zoo's first animal collection (HUBER, 1954). Until the late 1970ies, a varying collection of up to nine tortoise species was kept, then the number of species was gradually reduced, and today only two species are shown to the public in a house especially designed for giant tortoises. The largest Testudinidae collection, 8 species, is currently kept by Berne Zoo, where the prerequisites for the keeping of larger species were created as late as 1988 by the opening of the new vivarium.

Some twenty years ago, land tortoises (Testudinidae) used to be internationally traded in large numbers (HONEGGER, 1978). Every spring, truckloads of *Testudo graeca* and *hermanni* were transported from the Mediterranean area to Central Europe, where they were sold to the public at extremely low prices, and every autumn, zoos were "donated" more unwanted pet tortoises than they could accommodate. For the year 1974, Zurich Zoo reports no less than 221 tortoises and turtles that were "donated" to the zoo, and for the following year 227. The incentive to breed tortoises was, under these circumstances, rather low. So it is not amazing that a report on the breeding and egg-laying of reptiles at Berne Zoo, covering the period from 1944 to 1968, does not refer to tortoises (MEYER-HOLZAPFEL, 1969).

On 1st July 1975, the Convention on International Trade in Endangered Species of Wild Fauna and Flora entered into force in the first ten Party States, including Switzerland (DOLLINGER, 1979). This Convention lists all tortoise species in its appendices I or II, which means that they may be internationally traded only if accompanied by the import and export permits or certificates prescribed by the Convention. The impact on donations of chelonians to zoos was immediate: within one year, Zurich Zoo received 15 %, and within two years 35 % fewer animals than in 1975. As the number of Party States grew and as many of the European Parties implemented stricter domestic measures on the import of tortoises, the trade situation changed considerably: the supply became more irregular, because quota could be set or temporary trade bans be imposed by both the exporting and the importing countries, and the import figures generally decreased, especially in the Mediterranean species. An overview of this development is given in Table 1 (DOLLINGER, 1977 / 79 / 81 / 83 / 85; ALTHAUS and IRRALL, 1987 / 89 / 91; ALTHAUS et al.,1993 / 95). On the other hand, the prices saw a drastic increase - several hundred Swiss francs are now paid for an adult female Testudo hermanni - and tortoises are rather stolen from zoos than donated to them. Consequently, the interest in captivebreeding has increased considerably, which is illustrated by Table 2 (DUPLAIX-HALL, 1974, 1975, OLNEY, 1986, OLNEY, et al. 1994, OLNEY and FISKEN, 1995). Keeping conditions were improved, and zoos have to find means to protect their tortoises from theft. The same applies to private tortoise holders, who got organised in associations to exchange experience and animals. As a result of improved keeping conditions, more and more captive bred tortoises are exported from Switzerland, as is shown in Table 3 (DOLLINGER, 1977 / 79 / 81 / 83 / 85; ALTHAUS and IRRALL, 1987 / 89 / 91; ALTHAUS et al., 1993 / 95).

The present paper aims at giving an overview of the situation of, and of problems faced with land tortoises in the scientifically directed zoos of Switzerland.

¹ Note: In the present paper, the nomenclature of King and Bourke, 1989, is used, which is generally also followed by CITES.

Table 1 Number of land tortoises imported into Switzerland (even years only)								ly)		
Species	1976	1978	1980	1982	1984	1986	1988	1990	1992	1994
Chersina angulata	0	0	0	0	0	0	0	0	4	0
Geochelone carbonaria	96	65	66	11	20	68	0	0	13	2
Geochelone chilensis	0	0	0	0	0	2	0	0	15	0
Geochelone denticulata	0	8	302*	0	0	62	7	0	6	2
Geochelone elegans	50	46	3	5	39	0	0	0	0	0
Geochelone gigantea	0	0	1	2	4	0	0	0	0	2
Geochelone impressa	0	6	0	0	0	0	0	0	0	0
Geochelone pardalis	4	2	82	0	0	26	7	82	11	24
Geochelone radiata	3	0	5	0	0	0	0	0	0	0
Geochelone sulcata	0	0	12	0	0	29	0	5	15	6
Gopherus agassizi	0	0	0	1	0	0	0	0	0	0
Indotestudo elongata	27	64	16	0	0	12	5	0	0	25
Indotestudo forstenii	0	0	0	0	0	0	0	0	0	3
Kinixys spp.	3	41	54	38	0	756	0	18	0	88
Malacochersus tornieri	0	10	9	0	0	50	11	4	0	0
Manouria emys	0	16	0	0	0	0	6	0	0	0
Psammobates oculifer	0	0	10	0	0	0	0	0	0	0
Pyxis arachnoides	0	0	1	0	0	0	0	0	0	0
Testudo graeca	324	132	1158	2020	1	0	4506	0	1308	1120
Testudo hermanni	1802	4307	4194	5278	2858	988	0	3	0	51
Testudo horsfieldii	3476	1820	450	90	0	2	13	18	0	0
Testudo kleinmanni	0	0	0	0	0	0	0	0	0	4
Testudo marginata	79	10	20	150	0	0	0	0	0	0
Total	5864	6527	6383	7595	2922	1995	4555	130	1372	1327

* including one mixed shipment of carbonaria / denticulata

Table 2Number of reported to	land tortoises bre the International Zo	d in European / Medi o Yearbook	terranean zoos and
Species	1972/73	1982/83	1992/93
Geochelone carbonaria	0	7	44
Geochelone denticulata	0	0	1
Geochelone elegans	0	0	1
Geochelone nigra	0	0	4
Geochelone pardalis	0	0	22
Geochelone sulcata	0	0	11
Homopus areolatus	0	0	1
Indotestudo elongata	0	4	4
Kinixys belliana	0	0	6
Kinixys erosa	0	0	6
Kinixys homeana	0	0	8
Malacochersus tornieri	0	11	>17
Manouria emys	0	11	15
Testudo graeca	3	23	86
Testudo hermanni	10	21	987
Testudo horsfieldii	0	22	31
Testudo marginata	0	36	85
Testudo kleinmanni	6	0	0
Total	19	135	>1329

Table 3 Export of land tortoises captive bred in Switzerland (even years only)											
Species	1976	1978	1980	1982	1984	1986	1988	1990	1992	1994	
Geochelone pardalis	0	0	0	0	0	0	0	0	0	56	
Geochelone sulcata	0	0	0	0	0	1	11	85	109	71	
Testudo graeca	0	0	0	0	0	0	0	4	0	0	
Testudo hermanni	0	0	0	0	0	0	0	25	62	274	
Testudo marginata	0	0	0	5	8	0	42	137	202	313	
Total	0	0	0	5	8	1	53	251	473	714	

Legal requirements for the keeping of tortoises

The Swiss Federal Ordinance on Animal Welfare of May 27, 1981, subjects the keeping of giant and African spurred tortoises to licensing. According to Annex 2 of the ordinance, an indoor enclosure for one giant tortoise must measure at least 10 m², for one African spurred tortoise 8 m². For each additional animal, the surface has to be enlarged by 2 m². The tortoises must have access to a bath and, weather conditions permitting, to an outdoor enclosure of undefined size.

In the case of animals taken from the wild of species listed in Appendix I of CITES, an import permit will be granted only if the following standards set by the Scientific Authorities of Switzerland and Liechtenstein are met (DOLLINGER, 1977). For species listed in Appendix II, these standards serve as recommendations which are not legally binding:

Geochelone gigantea and *G. nigra*: outdoor enclosure of 100 m^2 and indoor enclosure of 24 m^2 for up to four animals. An extra 20 m^2 outdoors and 2 m^2 indoors are required for each additional animal.

G. pardalis, *G. sulcata* and *Manouria emys*: outdoor enclosure of 50 m² and indoor enclosure of 12 m² for up to four animals. An extra 10 m² outdoors and 2 m² indoors are required for each additional animal.

Medium-sized tropical land tortoises of up to 35 cm carapax length, such as *G. carbonaria* or *G. radiata*: indoor enclosure of 16 m² for up to four animals. An extra 2 m² are required for each additional animal.

Small-sized tropical land tortoises, such as *Homopus, Kinixys, Psammobates* and *Malacochersus:* indoor enclosure of 4 m² for up to four animals. An extra 0.5 m² is required for each additional animal.

Mediterranean tortoises (*Testudo* spp. including *horsfieldii*): outdoor enclosure of 8 m² for up to four animals with a heated shelter and a frost-resistent place for hibernation. An extra square meter is required for each additional animal.

All species should have permanent access to water. The recommended medium temperature for *Testudo* spp. is 15°, for all other species 24°.

Keeping facilities and group size

3.1 adult **radiated** (*Geochelone radiata*) and 1.1 **leopard tortoises** (*G. pardalis*) of **Basel Zoo** are kept in a 35 m² indoor exhibit with a concrete floor covered with sand. On an area of 8 m², the sand is 60 cm deep in order to allow the tortoises to deposit their eggs. The exhibit is completely separated from the visitors by a glass screen. The juvenile radiated tortoises are reared in a 3 m² terrarium behind the scenes. The floor is covered with a layer of sand, straw, hay and marl from the Jura Mountains. Furthermore, some leopard tortoises are kept off-exhibit: 1.0.2 in a 15 m² enclosure and 1.1 in a 5 m² enclosure. Both enclosures have a concrete floor covered with either marl and large flat stones, or with sand, and both have an area of about 1 m² where the tortoises can bury their eggs. The average temperature in the enclosures is 27.5°C. In the winter, the temperature is stable, while in the summer, when the windows are removed, night temperatures may be clearly lower.

Table 4Lighting of the tortoise enclosures at Basel Zoo (number of lamps x watts)							
Type of lamps	Exhibit	Off - G. pardalis 1	Off - G. pardalis 2	Off - A. radiata			
Day light (fluorescent I.)	10 x 36	2 x 36	-	-			
Mixed light (MLR 160)	-	1 x 160	1 x 160	1 x 160			
HQL	2 x 400	-	-	-			
Spots	5 x 120	2 x 120	3 x 120	3 x 120			
	3 x 300						
Natural light (window)	yes	no	yes	no			

At **Berne Zoo**, the **radiated tortoises** (G. *radiata*) are kept in an exhibit consisting of an indoor enclosure of 12.25 m², situated in a greenhouse-type building, and an adjoining outdoor enclosure of 28 m². The soil of both

enclosures is covered with a 30 cm layer of marl. Indoors, the marl is condensed and treated with water glass. Outdoors, it has a scarce grass cover. The enclosures are structured with natural rocks, they comprise a concrete drinking and bathing basin and a sandy spot of 0.5 m^2 where the tortoises can deposit their eggs. There are two hot plates of 1 m² each which reach a maximum temperature of 35°C. In addition, there are two 1000 W Par lamps. Both, hot plates and lamps are in operation during 10 hours per day. The indoor enclosure is separated from the public by a glass screen of 125 cm height. The **leopard tortoises** (*Geochelone pardalis*) have an indoor enclosure similar to that of the radiated tortoises. It is 12 m² in extent, and the soil is partly covered with quartzite sand. They share the enclosure with Yemen monitors (*Varanus yemenensis*). There is no outdoor enclosure.

The **wood tortoises** (*Geochelone carbonaria*) inhabit, together with lesser Malay chevrotains (*Tragulus javanicus*) and Goeldi's monkeys (*Callimico goeldii*), a 14 m² tropical forest exhibit which is planted with *Ficus benjamina* and Araceae species. The floor of the enclosure is covered with marl, mixed with lava sand, and partly covered with bark shred. There are two 100 W hot plates and lighting is ensured by fluorescent lamps. The tortoises hibernate on their own during two to three months.

The **hinged tortoises** (*Kinixys belliana* and *erosa*) have never been on exhibit. Their enclosure measures 9 m². It has a concrete floor, 1.5 m² of which is covered with a 15 cm layer of bark shred. Heated spots are provided during 10 hours per day by a 250 W Sikatherm lamp and a 160 W spot light. During winter, the animals fast for 2-3 months. The juveniles are reared in a terrarium with a ground cover of 2 cm, which should always be slightly humid. A 40 W spot light provides a temperature gradient.

The **soft-shelled tortoises** (*Malacochersus tornieri*) are kept in a 10 m² indoor exhibit landscaped so as to give the impression of a scree heap. The soil is covered with a 15 cm layer of quartzite sand (grain size 0.5 to 1 mm), and the technical installations are similar to those of the enclosure for radiated tortoises. The tortoises are kept together with rhinoceros iguanas (*Cyclura cornuta*).

The **Mediterranean tortoises** (*Testudo graeca, hermanni* and *marginata*) are kept in an outdoor enclosure of 50 m² with a sandy soil planted with of grasses, sea buckthorn and broom. There are several hides made from stone plates, and a heated shelter is provided. The tortoises hibernate in a separate room at a temperature of 10 to 14°C.

Table 5 Number of animals in the collection at the end of the year								
Species	Zoo	1990	1991	1992	1993	1994	1995	
Geochelone carbonaria	BE	0.0.1	0.0.1	2.1.0	2.0.0	2.0.0	2.0.0	
	ZH	0	0	9.5.1	9.4.1	8.3.1	8.3	
Geochelone gigantea	ZH	2.4.0	2.4.0	2.4.0	2.4.0	2.4.0	2.4.0	
Geochelone nigra	ZH	3.1.0	3.1.0	3.1.1	3.1.3	3.1.2	3.1.24	
Geochelone pardalis	BE	0	0	0	1.1.0	1.1.0	1.1.0	
	BS	2.4.0	3.4.0	2.2.13	1.2.13	1.2.8	1.1.5	
Geochelone radiata	BE	2.3.0	2.3.0	2.3.0	2.3.0	3.3.0	3.3.2	
	BS	4.1.0	4.1.0	4.1.0	4.1.0	3.1.11	3.1.11	
Kinixys belliana /K. b. noqueyi	BE	0	2.1.0	1.0.0	1.0.0	0	0	
Kinixys erosa	BE	1.3.0	1.3.0	1.2.0	1.2.0	1.2.0	1.2.0	
Malacochersus tornieri	BE	1.2.0	1.3.0	1.2.0	0.2.0	1.3.0	0.3.0	
Testudo graeca	BE	1.1.0	1.2.0	1.3.0	2.1.0	0.1.0	1.0.0	
Testudo hermanni	BE	0.0.12	3.5.0	6.6.11	9.7	0.1.0	1.2.6	
Testudo marginata	BE	0	1.2.0	1.2.0	6.2.0	1.0.0	1.0.0	
-	ZH	0.0.14	0.0.22	0	0	0	0	
Total		62	75	93	91	70	83 +	

The large group of **giant tortoises** (*Geochelone nigra* and *gigantea*) of **Zurich Zoo** was given a new summer enclosure in 1967. It measures approximately 40 x 8 m and comprises a mud bath, a 3.2 m² large, heated pool and a thermostatically controlled blockhouse shelter of 12.5 m². It has a grass cover and is planted with some shrubs and bushes under which the tortoises retreat during the hottest part of the day. A sand pit is also included which was readily accepted, first by a *G. nigra nigrita* female, as an egg deposit. At that time, the giant tortoises were moved to separate winter quarters where they stayed from October to May (HONEGGER, 1969). In 1979, a special tortoise house adjoining the summer enclosure with a 65 m² indoor exhibit was opened. Simultaneously, the summer enclosure was enlarged by 80 m². The indoor exhibit has a partially heated floor where the temperature reaches 30°C, a 6 m² muddy soil substrate area serving as a nesting site, and a 3.2 m² large and 30 cm deep pool. Infra-red and ultraviolet lamps were installed in 1988 to increase light and temperature locally (CASARES et al., 1995).

The **wood tortoises** (*Geochelone carbonaria*) of Zurich Zoo were housed in an indoor terrarium of 28 m² with a sky-light on a sand / gravel substrate and ample bark and root hiding facilities. During daytime, the ambient room temperature was 26° C, falling to 18° C at night. Two separate heat spots were provided under sun-lamps for eight hours per day. The room was additionally lighted by 4 x 40 W Vitalite tubes. From early May to the end

of September, the tortoises were moved to a permanent outside facility of 72 m^2 including a 4 x 2 x 0.5 m pool, with an adjacent heated shelter with a mean night temperature of 22° C, in which all animals, except egg-laying females were locked in at night or during colder days (below 12° C at 10.00 a.m.). During the day, the tortoises had access to the shelter at all times.

The **marginated tortoises** (*Testudo marginata*), and other **Mediterranean tortoises** that where occasionally donated by private persons (mainly *T. hermann*), used to be accommodated in an outside reptile enclosure.

Theft has become a major problem for zoos and has to be taken into account when accommodating tortoises. At Basel Zoo, the leopard and radiated tortoises used to be temporarily kept in an outdoor enclosure not visible to the public. When animals were stolen from this enclosure, it was decided to keep them indoors all year round, but even so 3 juvenile leopard tortoises were stolen in 1993, two of which were found and returned by the Police of Lausanne one year later. At Berne Zoo, a female radiated tortoise disappeared in 1987, a *Testudo graeca* in 1990, and as many as 19 *T. hermanni* and 8 *T. marginata* were stolen in 1994, including a marginated tortoise on loan from the Federal Veterinary Office, and 6 animals which had been confiscated by the Office in 1976 and had been kept at Zurich Zoo until 1992. Theft was one of the reasons why Zurich Zoo gave up the keeping of *T. hermanni* and *T. marginata* in 1992.

<u>Diet</u>

At **Basel Zoo**, juvenile and subadult leopard and radiated tortoises are fed daily on hay chaff. Twice a week, they receive different kinds (according to season) of scraped, but not mushy, or finely cut fruit and vegetables. On the other days, finely cut lettuce or chopped maize (leaves and spikes) and grass are fed. The fruit are peeled or rinsed. The food is given as early in the morning as possible. Once a month, raw quail's eggs or boiled hen's eggs, onions and cabbage are offered. The colour of the food may be important for its acceptance. While the radiated tortoises like red-coloured food such as tomatoes or strawberries, the leopard tortoises prefer inconspicuous or green-coloured food. All animals refuse to eat beetroot.

Main feeding of Basel Zoo's adult tortoises is on Mondays, Wednesdays and Saturdays. The animals receive the same types of fruit and vegetables as the juveniles, however less finely chopped, except for carrots or kohlrabi which have to be scraped to be accepted. Larger animals receive also plant material from the terrarium (*Ficus benjamina* and *Ficus repens*) or aquatic plants from the Aquarium. No vitamines are added, but calcium in the form of non-scraped sepia shell and marine algae powder to cover the need of iodine. The animals prefer to take the food directly from the ground, and both species pick marl up. The food is offered on two to three heaps to allow all individuals easy access. The food quantity varies depending on temperature and other factors. The figures shown in Table 6 have, therefore, to be taken only as an example. On the days between the main feeding, the animals receive only a little bit of lettuce or nothing at all. The animals become hungry and move more around in search of food. The animals drink mainly when the enclosures are cleaned with the water hose. The drinking basins are hardly ever used.

Table 6 Food consumption at Basel Zoo							
Animals	Quantity of	offered (g)	Leftov	Intake (g)			
Number, species, age	Fruit	Vegetables	in the evening	after 24 h	after 24 h		
3.1 G.radiata / 1.1 G.pardalis, adult	3600	3500	2200	700	4200		
0.0.2 <i>G.pardalis</i> , 4 y	600	500	150	150	950		
1.0.2 <i>G. pardali</i> s, 4 y, 2 y ,2 y	550	550	250	150	950		
0.0.11 <i>G. radiata</i> , juvenile	600	600	0	0	1200		

The feeding regime at **Berne Zoo** is quite different: Hay and lime are offered *ad libitum* to all species, and - with some seasonal variation - lettuce, wild herbs such as dandelion or plantain, grass, and other green fodder are fed daily. In addition the animals receive a feed supplement containing 15-16 % of crude protein and 7-8 % of crude fibre (Protector SA, No 2477). Sporadically, foliage is offered. Juveniles receive insects and earthworms as a source of animal protein. The radiated and leopard tortoises receive no fruit at all, the soft-shelled tortoises only small quantities, mainly kiwis, the hinged tortoises obtain half a banana per animal and week and, in addition, 1 to 2 minced adult mice. The wood tortoises are daily fed on fruit and vegetables, and once a week an adult mouse. The Mediterranean species have the opportunity to graze and their feed is daily supplemented with cut apples or other fruit and vegetables, and each animal receives 10 smelts (*Osmerus eperlanus*) per week. Juveniles and subadults up to four years of age receive animal protein daily (smelts and *Zophobas* larvae).

After the death of a very active and healthy *Geochelone gigantea* due to severe chronic interstitial and glomerular nephritis and severe visceral gout, **Zurich Zoo** altered, in 1984, the giant tortoise diet by improving the quality and reducing the quantity. The tortoises are now fed six times a week on a diet composed of 15 % vol. kale or red cabbage, 45 % vol. carrots, 30 % vol. different vegetables, 5 % vol. carob, 1.5 % vol. Ca-grit, 3 % vol. shredded horn or shrimp meal, and 0.5 % vol. Carnicon®. During summer, the grass cover of the outdoor

enclosure is an important feeding base and, in addition, grass and foliage are offered three times per week. During winter chopped hay is given three times per week. To make the tortoises more active, to increase their educational value, and to avoid social stress, the food is not offered in one feeding through, but is scattered around daily at irregular sites (HONEGGER and RÜBEL, 1991). When, in 1990, it was recognised that the first two Galapagos tortoises hatched at the zoo and reared for more than a year had suffered from a metabolic bone disease, also the diet of the juvenile tortoises was changed: protein was reduced, fibre raised and the Ca/P relation adjusted (HONEGGER et al., 1996). The wood tortoises were fed three times a week a vegetable (mainly kitchen greens, spinach etc., but no tomatoes), and fruit diet (low on bananas), supplemented with Capowder (sepia). Once a week, whole, gutted freshwater fish were offered and were readily eaten on land. No meat was offered. During the summer months, when the tortoises were housed in the outdoor area, they had access to grass, herbs, root and leaves of nearby trees at all times.

Breeding and survival

The following information is based on the animal registers. The tables consider all tortoises kept by the three zoos from 1990 to 1995.

While, at **Basel Zoo**, the radiated tortoises have never bred (since 1976), the leopard tortoises produced a total of 17 offspring. The animals hatched during the following months: January, February, April and November. Most eggs were collected and incubated at 28° C and 85-90 % humidity, in one case two young hatched in the exhibit from an undetected clutch of seven eggs.

From 1980 to 1989, **Berne Zoo** reported only the breeding of 17 *Testudo hermanni* and 4 *T. marginata*. As from 1989, the radiated tortoises laid eggs every year, however only in 1995, after a new male had been received as a breeding loan from Basel Zoo, two young hatched. The leopard tortoises produced offspring for the first time in 1996 with 5 hatchlings. In the same year also the first 4 Bell's hinged tortoises were bred. The only Mediterranean species having reproduced regularly is *Testudo hermanni*.

As from 1990, all four species kept by **Zurich Zoo** produced eggs annually. Hatchlings were, however, obtained only from the Galapagos giant tortoises (subspecific hybrids: *G. nigra becki x G. nigra nigrita*), for the first time in 1989 when, from a clutch of 12 eggs, the first two young hatched in a European collection. Extensive research on the reproductive physiology of both giant tortoise species at Zurich Zoo was carried out during 1992/93 (CASARES, 1995), and detailed accounts on the breeding and rearing of Galapagos giant tortoises by Zurich Zoo are given in HONEGGER and RÜBEL, 1991, HONEGGER et al., 1996, and by HATT and HONEGGER in this volume. In the previous decade, Zurich Zoo had also bred 26 *Geochelone carbonaria*, 21 *Testudo marginata* and 1 *T. horsfieldii*.

Table 7 Natality (X = eggs laid but no hatchlings, - = no females in the collection)								
Species	Zoo	1990	1991	1992	1993	1994	1995	Total
Geochelone carbonaria	BE	0	0	0	-	-	-	0
	ZH	-	-	-	Х	Х	Х	Х
Geochelone gigantea	ZH	Х	Х	Х	Х	Х	Х	Х
Geochelone nigra	ZH	Х	Х	0.0.1	0.0.3	Х	0.0.20	0.0.24
Geochelone pardalis	BE	-	-	-	0	0	0	0
	BS	0	0	0.0.14	0.0.3	0	Х	0.0.17
Geochelone radiata	BE	Х	Х	Х	Х	Х	0.0.2	0.0.2
	BS	0	0	0	0	0	0	0
Kinixys belliana	BE	-	0	-	-	-	-	0
Kinixys erosa	BE	0	0	0	0	Х	0	Х
Malacochersus tornieri	BE	Х	0	Х	0	0	0	Х
Testudo graeca	BE	0	0	0	0	0	-	0
Testudo hermanni	BE	0.0.6	Х	0.0.11	0.0.16	0.0.4	0	0.0.37
Testudo marginata	BE	-	0	0	0	-	-	0
	ZH	Х	Х	Х	-	-	-	Х

Of the 17 leopard tortoises bred at **Basel Zoo**, one died 5 days after hatching, all others could be successfully reared. In addition, a total of 12 adult or subadult leopard tortoises, one male and 11 females, died at Basel from 1963 to 1995. In 9 animals, the weight was determined. It varied from 2.8 to 12.2 kgs, with an average of 6.6 and a median of 5.3 kgs. Of the four radiated tortoises that were necropsied since 1976, two were males and two females. The body weights recorded were 0.4, 1.2 and 9.8 kgs.

Between 1991 and 1995, **Berne Zoo** lost 66.7 % of its 18 small tropical tortoises (*Kinixys* and *Malacochersus*). While, since 1990, 2 of the 4 *G. carbonaria* died as well, no deaths were recorded in *G. pardalis* and *G. radiata*.

Of 26 Galapagos tortoises (*G. nigra*) hatched at **Zurich Zoo** since 1989, the first two died suddenly at an age of 14 to 15 months, and one more was euthanised in 1995. The remaining 23 were successfully reared. No cases of death occurred in recent years in the adult giant tortoises of either species. Of the 22 wood tortoises (*G. carbonaria*) entering Zurich Zoo's collection in 1992, 10 (5 males and 5 females) have died so far, 7 of them in the course of an epizootic during November / December 1992. In 9 animals, the weight was determined. It varied from 2.3 to 4.92 kgs, with an average of 3.28 and a median of 3.58 kgs.

Table 8 Mortality								
Species	Zoo	1990	1991	1992	1993	1994	1995	Total
Geochelone carbonaria	BE	-	0	0	0.2.0	0	0	0.2.0
	ZH	-	-	4.2.0	0.1.0	1.2.0	0	5.5.0
Geochelone gigantea	ZH	0	0	0	0	0	0	0
Geochelone nigra	ZH	1.1.0	0	0	0	0	0.1.0	1.2.0
Geochelone pardalis	BE	-	-	-	0	0	0	0
	BS	0	0	1.2.1	0	0.1.0	0.1.0	1.4.1
Geocheloneradiata	BE	0	0	0	0	0	0	0
	BS	0	0	0	0	0	0	0
Kinixys belliana / b.noqueyi	BE	-	1.3.0	1.1.0	0	1.0.0	-	3.4.0
Kinixys erosa	BE	-	0	0.1.0	0	0	0	0.1.0
Malacochersus tornieri	BE	0	0	0.1.0	1.0.0	0.1.0	1.0.0	2.2.0
Testudo graeca	BE	0	0	0	0.1.0	2.0.0	0.1.0	2.2.0
Testudo hermanni	BE	0	0	0.1.0	0.0.1	0	0	0.1.1
Testudo marginata	BE	0	-	2.0.0	0.1.0	0	0	2.1.0
	ZH	+	+	+	-	-	-	+

The oldest animal in the collections today is the Galapagos tortoise (*G. nigra nigrita*) breeding female of **Zurich Zoo** which has been imported from the Galapagos islands in 1946, i.e. which is now more than 50 years old. The three males (2 *G. n. becki* and 1 *G. n. nigrita*) were imported in 1962 as juveniles (body weights 0.65, 2.35 and 7.45 kgs). 1.1 *G. gigantea*, in the collection since 1947 and, probably, 1948, died in 1984, i.e. after 36 and 37 years. The currently kept animals came to Zurich in 1955 (0.1), 1981 (1.0, as a loan from Stuttgart Zoo), and 1984 (2.1, as adults). 1.0 radiated tortoise (*G. radiata*) **Berne Zoo** received from Basel in 1994, had been in Basel Zoo's inventory since at least 1976. Of the radiated tortoises currently at **Basel Zoo**, one is pre-1976, and the others arrived in 1977 (2.0), respectively 1985. 0.2 leopard tortoises (*G. pardalis*) kept at Basel since October1965, died in 1992 respectively 1995. The current breeding pair was received in 1989, and the female was, at that time 8 to 10 years old.

Clinical histories, parasitology

The only clinical cases reported in **Basel Zoo's** leopard and radiated tortoises during the last 30 years concerned one animal with conjunctivitis and pneumonia, one biting wound on the neck (from another tortoise), and one animal which had to be euthanised (silting up of the intestine and dystocia). Periodical coprological surveillance revealed the presence of flagellates, ascarids and, most frequently, oxyurids (BRODBECK, 1988). For anthelminthic treatment fenbendazole (Panacur®, Hoechst, 50 mg/kg body weight) and levamisole (Citarin-L®, Bayer, 25 mg/kg body weight) were used.

Coprological examination of tortoises at **Berne Zoo** revealed the presence of coccidia, flagellates, ciliates, *Entamoeba,* Trematode eggs and nematode eggs and larvae. For anthelminthic treatment fenbendazole and albendazole (Valbazen®, Smith-Kline) were used, and dimetridazole (Emtryl®, Vemie) against protoza.

At **Zurich Zoo**, where the wood tortoises were found to be massively infested with oxyurids and trematodes, treatment with pyrantel pamoate (Molevac®, Parke-Davis, 5 mg/kg during 5 consecutive days) was attempted, followed by fenbendazole and praziquantel (Droncit®, Bayer) applications.

Pathological findings

A retrospective evaluation of pathological findings is made difficult by the fact that necropsies in reptiles are less systematically carried out than e.g. in mammals, and that many of the animals were already in a stage of more or less progressed autolysis when they were examined.

At **Basel Zoo**, the 16 necropsy reports (12 *G. pardalis* and 4 *G. radiata*) available contain 31 diagnoses which are summarised in Table 9.

Table 9 Pathological findings in Geochelone pardalis and radiata of Basel Zoo						
Infections (3)	1 generalised Aeromonas infection, 1 terminal sepsis and 1 generalised chronic infection (no agent identified)					
Parasites (2)	1 amehiasis 1 hevamitiasis					
Cardiovascular (2)	1 focal myocarditis, 1 arteriosclerosis					
Respiratory (1)	1 pneumonia					
Gastrointestinal (6)	1 chronic catarrhal enteritis, 1 diphtheroid pharyngitis and enteritis, 1 diphtheroid typhlocolitis, 1 gastritis, 1 necrotic enteritis and torsio caeci, 1 enteritis					
Hepatic (2)	1 focal lipidosis, 1 hemosiderosis					
Urinary (6)	1 tubulo-interstitial nephritis, 1 tubulonephrosis, 1 nephrosclerosis, 1 kidney gout, 2 visceral gout					
Genital (2)	1 salpingitis, 1 focal fibrosis of testicles					
Metabolic / other (7)	3 struma or enlarged thyreoidea, 1 calcification of oesophagus, intestine and salpinx, 2 kachexia, 1 no diagnosis					

At **Berne Zoo**, relatively few necropsy reports were available. In 7 juvenile *Testudo hermanni* that died in June 1996, an Iridovirus infection was suspected. In an earlier year, *Iridovirus* infection was excluded in a *Testudo hermanni* which showed an oesophagitis at necropsy. Sepsis and pneumonia were reported in another Hermann's tortoise, and a *Kinixys* showed a necrotic dermatitis.

One of the first two juvenile Galapagos tortoises that died at **Zurich Zoo** showed slight acute interstitial nephritis and acute interstitial thymitis, the second one a severe chronic interstitial pneumonia. Both animals had signs of metabolic bone disorder. The third young Galapagos tortoise (which was euthanised using 2 ml pentobarbital, Vetanarcol®, Veterinaria) was kachectic, had a congenital carapax anomaly and suffered from pneumonia.

In five wood tortoises (*G. carbonaria*), which died in November / December 1992, a virus infection was suspected but not proven. The first four animals were all males, the fifth a female. The animals showed stomatitis, glossitis, oesophagitis and enteritis, some of them also rhinitis, laryngitis and tracheitis and, in one case, incipient pneumonia. Oxyurids were found in large quantities in most animals. In the last one, a focal necrotic pneumonia and gastroenteritis due to a mycotic infection was diagnosed. This may be due to the fact that the animal concerned had been treated with antibiotics (Enrofloxacin, Baytril®, Bayer) for about three weeks. In 1993, a female wood tortoise died from an invagination of the jejunum, and, in 1994, another female from dystocia.

Discussion and conclusions

The **facilities for the keeping** of giant tortoises at Zurich Zoo meet both the requirements of Annex 2 of the Federal Ordinance on Animal Welfare and the recommendations of the Scientific CITES Authorities. At Basel Zoo, the indoor exhibit for leopard and radiated tortoises (for which no standard exists in the ordinance) exceeds the recommendations of the Scientific CITES Authorities. On the other hand, there is no outdoor enclosure, and one of the off-exhibit enclosures is clearly below the recommended standards. It should be stressed, however, that the enclosure surface and structure is only one factor to be taken into account for housing tortoises appropriately. Lighting (intensity, spectrum and duration) and the quantity and quality of the feed are equally important (ISENBÜGEL and FRANK, 1985; WARWICK et al., 1985). Nevertheless, Basel Zoo plans to address the issue and to construct a new enclosure for leopard tortoises in the context of a major development. At Berne Zoo, the various enclosures meet more or less the recommendations of the Scientific CITES Authorities, except for the leopard tortoise exhibit where an outdoor enclosure is missing.

Until 1984, an unbalanced **diet** containing a.o. 15 % vol. lettuce, 20 % vol. bananas, 30 % vol. tomatoes, 30 % vol. fruit and 5 % vol. minced meat, had caused metabolic disorders in the tortoises of Zurich Zoo, such as Osteodystrophia fibrosa, described by HAUSER et al. (1977) in four Aldabra giant tortoises kept for more than ten years, or visceral gout. At Basel Zoo, three cases of struma parenchymatosa or of enlarged thyreoidea were observed in radiated tortoises in 1976, 1980 and 1985. This phenomenon is known from species that feed on a diet poor in iodine, or on plants containing thyreostatic substances such as certain kinds of cabbage (ISENBÜGEL and FRANK, 1985). Such problems are avoided today by a more balanced diet, and, in the case of the radiated tortoises, by adding marine algae powder to the feed. Generally, the situation in the wild should be taken into account, e.g. the fact that animals are less active and that their food intake is reduced during hot and dry periods (MATZ and VANDERHAGE, 1990), and that, in spite of recommendations given in the literature (e.g. MÜLLER, 1993), the protein component of the diet should be rather small to prevent metabolic disorders such as osteodystrophia or visceral gout (BROGARD, 1987; HÄFELI and SCHILDGER, 1995). Most interestingly, the three zoos vary considerably in their dietary regimes, but in all cases the physiological and behavioural needs of the animals seem nowadays to be met. If the animals are kept indoors at a certain density, special precautions should be taken to avoid social stress due to envy.

Breeding has certainly improved in recent years, but is still not fully satisfactory. Of the 15 tortoise groups kept by the three zoos since 1990, 10 produced eggs, and in two more one can assume that they also laid eggs, which were not found by the keepers. Hatchlings were, however, obtained only from six groups, and the hatching rate was in most cases rather low. It seems that, in certain cases, the handling of the eggs by the staff needs some improvement. On the other hand, the **survival** rate of the hatchlings was extremely good. The longevity of the animals that were originally imported from the wild is good as far as the four larger species of the genus *Geochelone* are concerned. In *Geochelone carbonaria* and all the smaller tropical species, the mortality was too high, and the keeping conditions should be reviewed. In the Mediterranean species, the problem of theft should be addressed as a priority.

As far as **diseases** are concerned, it should be stressed again that the pathological diagnostic is hampered very much by the fact, that the material received by the institutes is very often in an autolytic stage, because the dead animals were not found, cooled down, and transported quickly enough. In two of the zoos, epizootics occurred which were suspected to be of viral origin. Although the diagnostic was not conclusive, one has to assume that the *Iridovirus* (Herpesviridae) infection, first described in Switzerland by HELDSTAB and BESTETTI in 1982, and reconfirmed in *Testudo hermanni* imported from former Yugoslavia in 1987 and in *Testudo graeca* imported from Turkey in 1990 (MÜLLER et al, 1988, MÜLLER et al., 1990), still poses a potential threat to tortoises kept in zoos. In conclusion, zoos should refrain from integrating even clinically healthy tortoises into their collection, unless they have been kept under quarantine conditions for a sufficiently long period of time, and the different species should be kept in clearly separated enclosures and hibernation facilities.

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Summary

Husbandry and pathology of land tortoises (Testudinidae) in Swiss zoos

As a consequence of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the availability and the appreciation of land tortoises has changed. More efforts are made to breed and to improve the survival of land tortoises. The paper describes changes in international trade patterns since 1975, the legal requirements for the keeping of tortoises in Switzerland, the keeping facilities and husbandry practices of the three major Swiss zoos, and provides information on the breeding, survival and pathology of tortoises in these zoos. The results are discussed and some conclusions are drawn on how to improve further the keeping of tortoises.

Zusammenfassung

Haltung und Pathologie der Landschildkröten (Testudinidae) in schweizerischen Tiergärten

Als Folge des Übereinkommens über den internationalen Handel mit gefährdeten Arten freilebender Tiere und Pflanzen hat sich die Verfügbarkeit und Wertschätzung der Landschildkröten verändert. Vermehrt werden Anstrengungen unternommen, die Tiere zu züchten und sie möglichst lange am Leben zu erhalten. Die Arbeit beschreibt Veränderungen im internationalen Handel seit 1975, die gesetzlichen Anforderungen für die Haltung von Schildkröten in der Schweiz und die Haltungseinrichtungen und -praktiken in den drei grösseren Tiergärten der Schweiz. Ferner wird über Zucht, Sterblichkeit und Todesursachen informiert. Die Ergebnisse werden diskutiert, und es werden Schlussfolgerungen für eine weitere Verbesserung der Schildkrötenhaltung gezogen.

Résumé

Détention et pathologie des tortues terrestres (Testudinidae) dans des parcs zoologiques suisses

Suite à l'entrée en vigueur de la convention sur le commerce international des espèces de faune et de flore sauvages menacées d'extinction (CITES), l'intérêt porté aux tortues terrestres a évolué. Les efforts se multiplient pour élever ces animaux dans des conditions optimales de captivité afin de prolonger leur vie autant que possible. Cette étude porte sur les modifications survenues sur le plan du trafic international depuis 1975, sur les exigences légales concernant la détention de tortues en suisse et sur les conditions de détention dans les trois plus grands jardins zoologiques suisses. De plus, elle comporte des informations sur l'élevage, la mortalité et les résultats d'autopsie. Après la discussion des résultats, des conclusions sont tirées afin d'améliorer encore la détention des tortues.

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Addresses of the authors: Dr. P. Dollinger, Bundesamt für Veterinärwesen, CH-3097 Liebefeld-Berne Dr. O. Pagan and Dr. T. Jermann, Zoologischer Garten Basel, CH-4054 Basel Dr. R. Baumgartner, c/o Kantonales Veterinäramt Zürich, CH-8006 Zürich R.E. Honegger, Zoologischer Garten Zürich, CH-8044 Zürich