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HUSBANDRY AND PATHOLOGY OF RODENTS AND LAGOMORPHS IN SWISS ZOOS

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Introduction

The present paper aims to give an overview of the keeping of rodents and lagomorphs (excluding domesticated rabbits, guinea pigs, golden hamsters, rats and mice) in the four scientifically directed zoos of Switzerland, to provide some information on animal health problems encountered in these species, and to make some recommendations regarding the prevention of diseases and accidents.

The keeping of rodents and lagomorphs has a long tradition in Swiss zoos. Basel Zoo, for instance already had a squirrel house and a marmot rock when it was opened in 1874 (SARASIN 1924). With some interruptions, American or European beavers¹ were kept from 1876 to 1968, capybaras from 1887 to 1958, and Alpine marmots from 1889 to 1995. Coypus and porcupines arrived for the first time in 1883, agoutis in 1888, and prairie dogs in 1893.

In all four zoos however, the number of species kept at any one time used to be comparatively small:

Since 1937, a total of 48 different rodent and lagomorph species have been kept at **Basel Zoo**. In 21 species, very few specimens (mostly one or two) were purchased between 1947 and 1959. They were kept under rather inadequate conditions, survived only for a short period of time without reproducing, and no pathological records are available. Currently, Basel keeps 7 rodent species, four of which are on exhibit and three more are intended to be shown to the public in the new „Etosha House“.

From 1944 to 1998, 3 species of lagomorphs and 20 species of rodents were kept at **Berne Zoo**, Berne is currently the only zoo in Europe to keep and breed all three European leporids, but only 6 rodent species are present.

Only five species have been kept from the 1960ies to date at the **Goldau Animal and Landscape Park**, namely the Alpine marmot, fat dormouse, coypu, brown hare and European mountain hare. Currently, there is a prolific breeding group of Alpine marmots and, after the death of its mate, one lonely European mountain hare in the park.

At **Zurich Zoo**, 21 different, mainly South American, rodent species and two lagomorph species were kept from 1954 to 1998. The current collection comprises five rodent species only, four from South America and one from South-East Asia.

Table 1: Rodent and Lagomorph species kept at the zoos of Basel, Berne and Zurich

	Basel Zoo 1937-98		Berne Zoo		Zurich Zoo 1954-98	
	n	Period	n	Period	n	Period
Rodents						
Giant squirrel (<i>Ratufa</i> sp.)	2	1959 - 1961				1954
Finlayson's squirrel (<i>Callosciurus finlaysoni</i>)	5	1979 - 1981				
Prevost's squirrel (<i>Callosciurus prevostii</i>)					5	1983 - 1998
Prairie dog (<i>Cynomys ludovicianus</i>)	106	1937 - 1998				
African striped squirrel (<i>Funisciurus</i> sp.)	4	1971 - 1972				
Alpine marmot (<i>Marmota marmota</i>)	167	1940 - 1995	102	1944 - 1998	58	1954 - 1976
Woodchuck (<i>Marmota monax</i>)	1	1949 - 1950				
Grey squirrel (<i>Sciurus carolinensis</i>)	2	1949 - 1952				

¹ for scientific names see Table 1

Eurasian red squirrel (<i>Sciurus vulgaris</i>)	24	1945 - 1953				
Rock chipmunk (<i>Spermophilus californicus</i>)	2	1949 - 1951				
Golden-mantled ground sq. (<i>Sp. lateralis</i>)	2	1949 - 1952				
13-striped ground sq. (<i>Sp. tridecemlineatus</i>)	12	1958 - 1959				
Am. red squirrel (<i>Tamiasciurus hudsonicus</i>)	2	1949 - 1950				
Eastern chipmunk (<i>Tamias striatus</i>)	1	1949 - 1951				
Asian Chipmunk (<i>Tamias</i> sp.)	41	1963 - 1978			16	1957 - 1975
African ground squirrel (<i>Xerus inauris</i>)	8	1998				
American beaver (<i>Castor canadensis</i>)	3	1949 - 1957	59	1959-1998	181	1954 - 1992
European beaver (<i>Castor fiber</i>)	3	1958 - 1964	3	1957-1994		
Springhaas (<i>Pedetes caffer</i>)	5	1949				
African pouched rat (<i>Cricetomys gambianus</i>)					5	1965
Hamster (<i>Cricetus cricetus</i>)	4	1952 - 1954	10	1944 - 1978		
Short-tailed gerbil (<i>Diplodillus</i> sp.)	2	1957				
Egyptian gerbil (<i>Gerbillus perpallidus</i>)			28	1995 - 1996		
Giant jumping rat (<i>Hypogeomys antimena</i>)			10	1994 - 1998		
Jirds (<i>Meriones</i> 2 spp.)	3	1952, 1957				
Bank vole (<i>Clethrionomys glareolus</i>)			2	1981 - 1982		
Norway lemming (<i>Lemmus lemmus</i>)			44	1975 - 1976		
Common vole (<i>Microtus arvalis</i>)	10	1946 - 1948				
Muskkrat (<i>Ondatra zibethicus</i>)			13	1981 - 1992		
Spiny mouse (<i>Acomys cahirinus</i>)	64	1963 - 1971	3	1992 - 1993		
Wood mouse (<i>Apodemus sylvaticus</i>)	20	1945 - 1950				
Grass mouse (<i>Lemniscomys barbarus</i>)	40	1996 - 1998				
African pygmy mouse (<i>Mus minutooides</i>)	100+	1996 - 1998				
Harvest mouse (<i>Micromys minutus</i>)	5	1952	51	1952 - 1997		
Garden dormouse (<i>Eliomys quercinus</i>)	14	1946 - 1955	24	1945 - 1988		
Fat dormouse (<i>Glis glis</i>)	34	1945 - 1953	46	1944 - 1996		
Hazel dormouse (<i>Muscardinus avellanarius</i>)			15	1944 -1950		
Desert Jerboa (<i>Jaculus jaculus</i>)	4	1955 - 1958	2	1950		
Crested porcupine (<i>Atherurus africanus</i>)	1	1955 - 1961				
Porcupines (<i>Hystrix cristata</i> or <i>leucura</i>)	49	1939 - 1998	18	1995 - 1998	11	1939 - 1968
Prehensile-tailed p. (<i>Coendou prehensilis</i>)					12	1958 - 1994
American porcupine (<i>Erethizon dorsatum</i>)					28	1963 - 1982
Wild cavy (<i>Cavia aperea</i>)			4	1978	424	1984 - 1998
Patagonian cavy (<i>Dolichotis patagonum</i>)					4	1964 - 1966
Cuis (<i>Galea musteloides</i>)	8	1982			205	1978 - 1982
Capybara (<i>Hydrochochaeris hydrochaeris</i>)	32	1947 - 1958	25	1995 - 1998	163	1966 - 1998
Pacarana (<i>Dinomys branickii</i>)	1	1963 - 1972			24	1968 - 1979
Paca (<i>Agouti (Cuniculus) paca</i>)	1	1947 - 1950			2	1964 - 1973
Sooty agouti (<i>Dasyprocta fuliginosa</i>)	4	1975 - 1977			4	1970 - 1975
Golden agouti (<i>Dasyprocta leporina = aguti</i>)	111	1937- 1998	4	1992 - 1998	30	ca.1953 - 98
Green acouchy (<i>Myoprocta a. prattii</i>)					3	1989 - 1992
Plains viscacha (<i>Lagostomus maximus</i>)					316	1964 - 1998
Longtailed chinchilla (<i>Chinchilla laniger</i>)	105	1949 - 1978			110	1959 - 1983
Coypu (<i>Myocastor coypus</i>)	194	1943 - 1998	94	1944 - 1998		
Degu (<i>Octodon degus</i>)			48	1995		
Gondi (<i>Ctenodactylus gondii</i>)	2	1947 - 1951				
African mole rat (<i>Cryptomys</i> sp.)	7	1951, 1954				
Lagomorphs						
European brown hare (<i>Lepus europaeus</i>)	160	1944 - 1967	221	1945 - 1998	39	ca. 1966 - 85
European mountain hare (<i>Lepus timidus</i>)	4	1947 - 1950	75	1944 - 1998	14	1958 - 1970
Wild rabbit (<i>Oryctolagus cuniculus</i>)	27	1945 - 1953	211+	1971 - 1998		
Cottontail (<i>Sylvilagus floridanus</i>)	1	1949 - 1951				

Legal requirements for the keeping of rodents and lagomorphs

The Swiss Federal Ordinance on Animal Welfare of May 27, 1981, subjects the keeping by private persons of all mammals, except insectivores and small rodents to licensing. The term „small rodents“ is not defined but has to be derived from Annex 2 of the ordinance containing minimum requirements

only for species the size of squirrels / acouchies and larger. "n" in the tabulation means number of adults; in addition, juvenile or subadult offspring may be kept.

Table 2 Legal minimum requirements for the keeping of rodents and lagomorphs in Switzerland

Species	n	for groups up to n animals				for each animal		additional indoors	plus pool
		outdoor enclosure		indoor enclosure		outdoors			
		surface m ²	volume m ³	surface m ²	volume m ³				
Squirrels (red squirrel)	2	-	8	-	-	2 m ²	-		
Coypu, wild form	2	5	-	-	-	0.5 m ²	-	1 m ³	
Giant squirrels, coendus, pacarana	2	-	-	-	16	-	2 m ²		
Agoutis, acouchies	5	6	-	6	-	1 m ²	1 m ²		
Pacas, viscachas	5	-	-	8	-	-	1 m ²		
Porcupines	2	10	-	-	-	2 m ²	-		
Beaver, mara, hares	2	20	-	-	-	4 m ²	-	beaver only: 12 m ² / 6 m ³	
Prairie dogs, pikas	5	20	-	-	-	2 m ²	-		
Springhaas	5	-	-	10	-	-	2 m ²		
Marmots	1 0	100	-	-	-	10 m ²	-		
Capybara	2	40	-	10	-	10 m ²	2.5 m ²	4 m ² / 62m ³	

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. For all other species, these standards serve as recommendations and are not legally binding:

Table 3 Swiss CITES recommendations for the keeping of rodents and lagomorphs

Species	n	for groups up to n animals				for each animal		additional indoors	plus pool
		outdoor enclosure		indoor enclosure		outdoors			
		surface m ²	volume m ³	surface m ²	volume m ³				
Hares	2	40	-	-	-	4 m ²	-		
Wild rabbits	5	30	-	-	-	3 m ²	-		
Pikas	5	20	-	-	-	2 m ²	-		
Boreal squirrels	2	8	20	-	-	1 m ² / 2 m ³	-		
Tropical squirrels	2			8	20		1 m ² / 2 m ³		
Flying and giant squirrels, coendus, pacarana	2			16	40		2 m ² / 5 m ³		
Coypu, wild form	2	10	-	-	-	1 m ²	-	10 m ² / 5 m ³	
Beaver	2	40	-	-	-	4 m ²	-	15 m ² / 10 m ³	
Porcupines, mara	2	40	-	-	-	4 m ²	-		
Springhaas, agoutis	2	20	-	20	-	1 m ²	1 m ²		
Pacas, viscachas	2		-	20	-		1 m ²		
Prairie dogs	1 0	40	-	-	-	2 m ²	-		
Marmots	1 0	150	-	-	-	10 m ²	-		
Capybara	2	150	-	20	-	10 m ²	2.5 m ²	2 m ³	

Keeping facilities and group size

Basel Zoo

From 1944 to 1953, Basel Zoo ran a flourishing brown hare breeding project. At that time, when no potent coccidiostatica and anthelminthica were available, this success was possible only because the then director of Basel Zoo, Heini Hediger, developed the so-called „mirror cages“ consisting of two compartments of 2.4 m² interconnected by a trap door. Each mirror cage served to keep one pair of hares and their juvenile offspring. Only one compartment was occupied by the hares. At 48 hour intervals, the trap door was lifted, the hares moved into the other compartment where they found fresh food and bedding, and the used compartment was immediately cleaned (HEDIGER, 1951).

The capybaras used to be kept on the so-called “Festmatte”, the old show grounds with a surface of approximately 3000 m², where they were associated with sheep, goats, ponies, and various bird species. The indoor quarters were in the „Winter stable“, where they occupied one or two boxes next to domestic ungulates.

An artificial rock structure divided into two enclosures, each with a pool, was originally the home of beavers or coypus and of otters or raccoons. Today, both enclosures have been made available to the coypus. Alpine marmots, porcupines, prairie dogs and golden agoutis were, or still are, kept on the „Rodent Rock“, an artificial rock structure designed in 1922. On a total area of 360 m², the rock contained originally five enclosures, which recently have been reduced to three. The enclosures are not fenced on top, i.e. they are accessible to peacocks and other free-flying or wild birds, and are occasionally visited by free-living predators. It is intended to move the porcupines to the new „Etosha House“, where they will have improved indoor and outdoor facilities. In this house the African ground squirrels will occupy a large indoor enclosure together with yellow mongooses (*Cynictis penicillata*) and meerkats (*Suricata suricatta*). In case of conflicts between the species, it will be possible to subdivide the enclosure. Two African mouse species (*Mus minutoides* and *Lemniscomys barbarus*) will be kept in smaller, glass-fronted indoor enclosures.

Table 4 Enclosure size at Basel Zoo

Species	n spec.	outdoor enclosure	indoor enclosure	pool / associated with
Alpine marmot (old)	up to 10	100 m ²		
Prairie dog (old)	ca. 20	60 m ²	1 x 2 m ²	
Prairie dog (new)	ca. 20	120 m ²	2 x 2 m ²	
Ground squirrel (future)	ca. 10	0	ca. 150 m ²	birds, meerkat , yellow mongoose
Beaver (old)	2	ca. 12.5 m ²	ca. 2 m ²	+ pool ca. 12.5 m ²
Striped mouse (future)	ca. 20	0	2 m ²	
Pygmy mouse (future)	ca. 20	0	1 m ²	
Golden agouti (old)		50 m ²	ca .5 m ²	
Golden agouti (new)	8	180 m ²	7.5 m (4 compartments)	
Porcupine (current)	2.4 + 3 juv.	60 m ²	6 m ²	
Porcupine (future)		75		
Coypu	2.5 + 14 juv.	ca. 25 m ²	5. 5 m ²	+ pool ca 25 m ²

Berne Zoo

During some time, hares used to be kept in “Hediger cages” as described above. While the beavers and coypus had facilities that were relatively small, the marmots were always kept in a fairly spacious enclosure. The keeping of dormice was without any purpose from a visitor’s point of view because they were kept in cages without day-night reversal, i.e. were not visible during the opening hours of the zoo. Until it was completely rebuilt, the “Vivarium” contained several small terraria, some of which were used for keeping small rodents.

Today, agoutis and Malagasy giant jumping rats are housed in the “Vivarium”, where they are kept indoors all the year round, the Malagasy rats in a nocturnal exhibit together with mouse makis, the agoutis in a large glass-fronted South America exhibit together with hyacinthine macaws. Naturalistically decorated outdoor cages of the former Carnivore House or aviaries are used for the keeping of lagomorphs. Currently, two aviaries of the former Pheasantry are combined and rebuilt as a spacious and educational exhibit for mountain hares and ptarmigans (*Lagopus mutus*). Brown hares are also associated with ungulates, as are some of the marmots. The other species have specifically designed outdoor enclosures with dens or stables as appropriate.

Table 5 Enclosure size at Berne Zoo

Species	n adults	outdoor enclosure	indoor enclosure	pool / associated with
Alpine marmot		151 m ² , 687 m ²	0	chamois (<i>Rupicapra rupicapra</i>)
Malagasy giant jumping rat		0	11,6 m ²	mouse maki (<i>Microcebus murinus</i>)
Harvest mouse		5 m ²	0	
Beaver	2	173 m ²	5.7 m ²	pool included, golden-eye sand other ducks
Porcupine		48 m ²	2.6 m ²	
Golden aguti	2	0	24 m ²	hyacinthine macaw (<i>Anod. hyacinthinus</i>)
Capybara	2	436 m ²	15.5 m ²	pool included
Coypu		81.7 m ²	4.1 m ²	pool included
Brown hare		24 m ² , 1993 m ²	0	birds / roe deer (<i>Capreolus capreolus</i>)
European mountain hare		17 m ² , 30.6 m ²	0	birds / bearded vulture (<i>G. barbatus</i>)
Wild rabbit		24 m ²	0	birds

Goldau Animal and Landscape Park

While some of the former exhibits were rather inadequate, the current enclosures are very spacious, containing natural rocks and a grass cover. The Alpine marmots have been kept together with roe deer since 1982, and the European mountain hares together with bearded vultures since 1995.

Table 6 Enclosure size at Goldau Animal and Landscape Park

Species	n spec.	outdoor enclosure	associated with
Alpine marmot	10	900 m ²	roe deer (<i>Capreolus capreolus</i>)
European mountain hare	2	805 m ²	bearded vulture (<i>Gypaetus barbatus</i>)

Zurich Zoo

The old main building contained a series of glass-fronted cages, each with a ground surface of 3 m². Some of these were used for the exhibition of rodents. Successively, the number of species was reduced and walls between cages removed to give the animals more space. Indoor enclosures for the capybaras and viscachas were located in the basement of the same building. The American beavers were kept and bred successfully in two exhibits originally designed for seals and otters with a land surface of 24 m² and 14 m² respectively, and a water surface of 38 m² and 20 m² respectively. Until 1976, the Alpine marmots were kept in a relatively shadowy enclosure from where they dug a system of burrows into the neighbouring pygmy goat and emu enclosures. Later on the same enclosure was used for keeping American porcupines. Brown hares – mostly animals received from the wild and hand-reared - were allowed to roam freely in the zoo.

Today, the rodents are kept in the South America House and in the Elephant House. Only two species have access to outdoor exhibits, but the indoor facilities are comparatively spacious and well structured, e.g. with tussocks in the capybara and cavy enclosures or roots and hills in the viscacha enclosure. Separation enclosures are provided, and there are dens for the viscachas, overhanging rock structures for the wild cavies, and an indoor pool for the capybaras. The floor is covered either with bark chips or sand (cavies, viscachas), and there are live trees in the agouti enclosure. Four of the five species in the collection are associated with either birds or other mammals. On their grass-covered outdoor enclosure, the capybaras are associated with giant anteaters and lowland tapirs. Indoors the three species are normally kept separate, and tapirs and capybaras rotate in having access to the indoor pool

Table 7 Enclosure size at Zurich Zoo

Species	n adults	outdoor enclosure	indoor enclosure	pool / associated with
Prevost's Squirrel	1-2	18 m ² / 27 m ³	20 m ² / 52 m ³	bamboo partridge (<i>Bambusicola thoracica</i>)
Golden agouti	2	0	37 m ² + 6.8 m ²	birds, tamarins, marmosets
Wild cavy	8	0	7.5 m ² + 2.5 m ²	
Plains viscacha (old)	10	0	13 m ²	

Plains viscacha (new)	8	0	28 m ² + 8 m ²	burrowing owl (<i>Speotyto cunicularia</i>)
Capybara (old)	2	190 m ²	14 m ²	tapir (<i>T. terrestris</i>) indoors separate
Capybara (new)	2	330 m ²	18 m ² + 23 m ² + 21 m ²	pool 10 m ³ / anteater (<i>M. tridactyla</i>), tapir (<i>T. terrestris</i>), indoors separate

Diet

Information on the diet of the species kept at **Basel Zoo** is summarised in Table 8. Indications of weight are per animal. The seeds given to the grass and pygmy mice are a commercial feed for siskins and goldfinches (Schweizer Samen: Distel- und Zeisigfutter). The pygmy mice are not particularly keen on fruit and vegetables, and they receive mealworms at irregular intervals only.

Table 8 Diet of the species currently kept at Basel Zoo

	Grass or hay, branches	Rolled oats, barley, sun flower seeds, peanuts	Other	Fruit and vegetables		
				Apples, pears, oranges, bananas etc.	Broccoli, fennel, beet-roots, carrots, cucumbers ..	Total weight of fruit and vegetables
Prairie dogs ¹	ad lib.	50 g		x	x	75 g
Ground squirrels ²	ad. lib	x	dry cat food	x	x	
Grass mice ²	ad lib.	x	dry bread, seeds	x	x	
Afric. pygmy mice ²	ad lib.		meal worms, seeds	(x)	<8x<9	
Porcupines ¹	ad. lib.	80 g		x	x	1100 g
Golden agoutis	ad. lib.	50 g		x	x	900 g
Coypus ²	ad lib.	x		x	x	
¹ seasonal variation						
² no information on weight available						

At **Berne Zoo**, the feeding regimes are the following:

Marmots (2 adults, 1 juvenile): hay (2nd cut) *ad libitum*, 300 g pellets (Protector 941®), 2 apples, 3 carrots, 3 pc. of hard bread

American Beaver (2 adults): branches of willow, poplar and coniferous trees, 250 g pellets (Protector 941®), 2 apples, 3 carrots, iodinated salt, mineral mix (on 3-5 days per month). Sunday is the day of fasting.

Malagasy jumping rat (per animal): 150 g fruit or vegetables, 100 g salad, 5 ml mineral mix, 50 g guinea pig pellets (2x/week), 50 g boiled cereals (2x/week), 50 g hard bread (1x/week), occasionally branches.

Capybara (2 adults, 6 juveniles): hay, straw and branches *ad libitum*, 1400 g pellets (Protector 953.2®), ca. 11.2 kg mixed fruit and vegetables, 6.5 kg salad and mangold.

Golden agouti (per animal): 350 g fruit, vegetables, salad and nuts, 5 ml mineral mix, 50 g boiled cereals, occasionally branches.

Coypu (9 adults, 6 juveniles): hay, straw and branches *ad libitum*, 1300 g pellets (Protector 951.7®), ca. 8.5 kg mixed fruit and vegetables.

Lagomorphs (2 adults): hay, branches of birch, oak, willow (*Salix cinerea*), fruit trees, and raspberry tendrils *ad libitum*, pellets (Protector 941®) during summer *ad libitum*, during winter 110-120 g. No fruit or vegetables.

At **Zurich Zoo** the following daily rations are offered per adult animal:

Prevost's squirrel: cut fruit pinned to the climbing branches (avocado is their favourite, apples, pears and oranges are readily taken, melons and grapes less so), a small bit of hard bread, opened walnuts and peanuts, vegetables (carrots, fennel, celery, mangold, tomatoes)

Wild cavy: hay *ad libitum*, grass, branches of fruit trees, sepia shell, guinea pig pellets NAFAG, ¼ apple, 1 salad leaf, ½ carrot, otherwise no vegetables, no bread.

Capybara: the basic ration consists of hay and/or grass, branches or bamboo *ad libitum*, 5-6 apples, 4-10 carrots, 1 head of salad, barley sprouts, ca 40 g horse pellets, hard bread, in addition vegetables such as lettuce, fennel, celery, mangold, cauliflower (few), tomatoes, and fruits such as pears, grapes, bananas are offered according to season.

Golden agouti: 1 peanut, 1 walnut, ¼ apple, ¼ banana, grapes, 1 mangostane (favourite food !), 1 carrot, ½ fennel, other vegetables as available, barley sprouts, willow branches, 1 small piece of hard bread, rodent pellets (are not readily accepted).

Viscacha: hay and branches *ad libitum*, pellets (Multiforsa 21), apples, salad, carrots, bread.

Breeding and survival

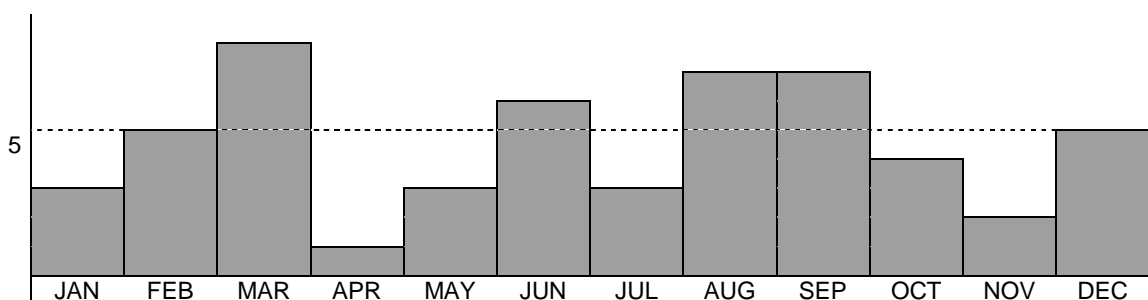
31 of the 63 species kept during the periods shown in Table 1 bred successfully, some of them in large numbers, so that surplus animals had to be euthanatised or slaughtered and used for feed. Alpine marmots were bred by all four zoos, porcupines, capybaras and European brown hares by Basel, Berne and Zurich, and coypus by Basel, Berne and Goldau.

In the *Alpine marmot* population of Basel Zoo, productive periods alternated with series of years where no births were recorded. Although Basel is at an altitude of about 250 m above sea level only, most young left the den for the first time in June, as they do in their alpine habitat. Breeding at Berne Zoo was rather erratic. At Goldau Animals and Landscape Park the marmots have produced a total of 25 cubs since they were moved to the roe deer enclosure in 1982. At Zurich Zoo, a new group of marmots had to be established after all animals had died while hibernating in their self-dug burrows during an extremely cold winter. The new group produced and reared a total of 28 cubs in all years but one from 1966 to 1975. The average size of 43 litters leaving the burrows at Basel, Berne and Zurich was 3.42 (min. 1, max. 7, median 3).

After sporadic breeding (2 litters) in the period from 1939 to 1979, the *porcupines* of Basel Zoo started breeding fairly regularly in 1982 when they were moved to a new enclosure. Since then, 10 litters with one young and 9 litters with twins have been produced. With 15 offspring (5 x singles, 5 x twins) the porcupines at Berne Zoo were similarly productive during the period when they were kept in a new enclosure at the Children's zoo. No seasonality of reproduction was observed in porcupines.

During the periods reviewed, the *capybaras* at the zoos of Basel, Berne and Zurich produced 55 litters with a total of 192 young. Litter size was 5 x 1, 9 x 2, 13 x 3, 17 x 4, 5 x 5, 5 x 6, and 1 x 7 (mean 3.49, median 4). The average birth weight at Basel Zoo (n=24) was 1530 grams (min. 700 g, max. 1935 g, median 1600 g).

The *golden agoutis* had, from 1948 to 1998, 42 litters with a total of 89 young at Basel Zoo, and from 1954 to 1995 12 litters with 20 young at Zurich Zoo. Litter sizes were 22 x 1, 16 x 2, 11 x 3, 4 x 4 and 1 x 6 (mean 2.12, median 3). As in other tropical or subtropical species, no seasonality was observed (graph 1), although the animals at Basel had access to outdoor enclosures. Average birth weight at Basel Zoo (n = 10) was 151 grams (min. 80 g, max 195 g, median 165 g).

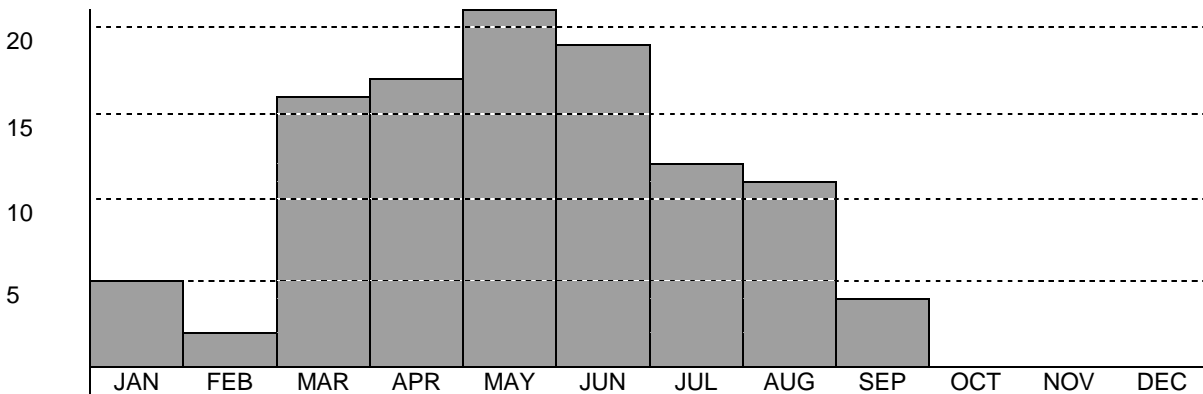


Graph 1 Seasonal distribution of golden agouti (*Dasyprocta aguti*) litters at Basel Zoo (1 litter not known) and Zurich Zoo

During the periods reviewed, a total of 174 young *brown hares* in 109 litters (mean 1.59) were born at Basel and Berne. In 56 cases, litter size was one, 43 litters consisted of twins, 8 of triplets and 2 of

quadruplets. Average birth weight at Basel Zoo (n = 52) was 134 grams (min. 58 g, max 310 g!), median 130 g).

The seasonality of the births is shown in graph 2. Obviously the mating season in captivity starts approximately one month earlier than in the wild (see BAUMANN, 1949; HAUSSER et al. 1995). In the *European mountain hares* bred at Berne at an altitude of 520 m, all births occurred from May to August, and this lies within the reproduction period in the natural alpine or subalpine (1300 m and higher) habitat.



Graph 2 Seasonal distribution of brown hare litters at Basel Zoo

Mortality and pathology

Rodents and lagomorphs are short-lived creatures. At Berne Zoo, the oldest animals in the collection today are a brown hare of 7 years, a mountain hare of 6 years, an American beaver of 4 years, a capybara of 4 years, and wild rabbits of 2 years. Of the 333 rodents kept by Zurich Zoo from 1992 to 1998, 166, i.e. 50 %, died or had to be euthanised for medical reasons during this period. Nevertheless, no attempt is made to present pathological statistics in this paper because in many cases, no necropsies could be performed, the material being already autolytic or the animals being reported as having "disappeared" or "did not reappear after hibernation", such as 3 of 11 prairie dogs that died from 1992 to 1998 at Basel Zoo. In recent years, the zoos have undertaken every effort to submit dead animals for necropsy, but often no causative agents could be identified, or pathological pictures were far from permitting a clear assessment of the cause of death. As an example, 10 of the 31 capybaras that died at Basel Zoo had suffered from intestinal diseases, including granulomatosis of the colon, gastroenteritis and enterocolitis, but it is not known what had caused this accumulation of intestinal problems.

Reference is made to the publications by DOLLINGER (1971) on death through behaviour in zoo animals, by RÜBEL et al. (1989) on viscachas and by ISENBÜGEL et al. (1990) on capybaras, which provide statistical data on mortality and pathology at Zurich Zoo. In this paper, we limit ourselves to pinpointing several observations or problems that were not previously published.

Tuberculosis

A porcupine that had been transferred from Zurich to Basel Zoo in 1944 died one year later from tuberculosis. In the period from 1956 to 1958, when they were kept together with domestic ungulates, at least five capybaras of Basel Zoo succumbed to tuberculosis caused by *M. bovis*. From 1978 to 1982, a total of 16 cuis died at Zurich Zoos of pulmonary diseases. In some cases, acid-fast bacteria were identified, but their typisation was not successful.

Yersiniosis

From 1968 to 1988, 6 of 29 golden agoutis necropsied at Basel Zoo had died of yersiniosis. While in recent years, no more cases have been observed in the rodent collection nor in wild caught mice at Basel Zoo, *Yersinia pseudotuberculosis* continued to cause deaths in all rodents kept at the South America House of Zurich Zoo, i.e. wild cavies, cuis, viscachas, agoutis and capybaras. In 1996 and 1997, 7 of the capybaras at Berne Zoo (which were related to those of Zurich) died of yersiniosis. In

addition, Berne Zoo lost at least 2 Norway lemmings, 9 European brown hares and one European mountain hare as a result of this disease.

Leptospirosis

Major problems caused by *Leptospira icterohaemorrhagiae* in American beavers of Zurich Zoo have already been described by METTLER et al. (1974) and continued to exist, although in many cases, the agent was suspected on the basis of the pathological pictures but was not identified. There are no proven cases of leptospirosis in the other zoos, but three of the six beavers that died at Basel Zoo showed pathological changes of the kidneys.

Salmonellosis

In 1989, *Salmonella typhimurium* was identified in wild mice caught at Basel Zoo. At Berne Zoo, *Salmonella enteritidis* was observed in one American Beaver that died of streptococcosis and was the cause of death of three European brown hares and one European mountain hare. Salmonellae were also a major problem in the gerbil colony of Berne Zoo. In 1963, salmonellosis caused the death of two prehensile-tailed porcupines at Zurich Zoo.

Erysipelas

In 1998, a case of erysipelas occurred in a mountain hare associated with bearded vultures (*Gypaetus barbatus*) at Berne Zoo.

Protozoa

Lambliasis was diagnosed in 2 chinchillas and one coypu, coccidiosis of the liver (*Eimeria stiedae*) in a wild rabbit, and *Eimeria* sp. and *Cryptosporidium* sp. were frequent *intra vitam* diagnoses in the brown hares of Basel Zoo. At necropsy, coccidiosis was found in one Alpine marmot and 11 European brown hares of Berne Zoo. The coccidia were identified as *Eimeria europaea*, *E. hungarica*, *E. irresidua*, *E. leporis*, *E. perforans*, *E. semisculpta* and *E. townsendi*.

Helminths

Trichuris leporis and *Trichostrongylus retortaeformis* were regular findings in necropsied brown hares of Berne Zoo. In one mountain hare, a *Coenurus serialis* cyst was found. At Zurich Zoo, infestation by *Paraspidodera* sp. (Oxyuridae) was detected in wild cavies freshly imported from Argentina. Other *intra vitam* findings in Swiss Zoos include ascarids, "strongylids", *Protostrongylus pulmonalis*, *Graphidium* sp., *Strongyloides* sp. (in coypus), *Passalurus ambiguus*, *Trichuris* sp. and *Capillaria* sp.

Ectoparasites and ringworm

Trichophyton infections are a problem in the viscacha colony of Zurich Zoo, and in two agoutis that were necropsied at Zurich, fleas were detected.

Struma

Strumata were found in an American beaver kept for seven years (in 1957), and in two coypus (in 1946, 2.5 and 3 years old) of Basel Zoo, and strumata as big as a fist were observed also in 4 coypus of Berne Zoo. In one case, the weight was 250 grams.

Neoplasms

In a male marmot that died in 1950 at Basel Zoo, the diagnosis was "carcinoma ventriculi". An adenocarcinoma in the liver with metastases in the lung vessels was diagnosed in another male marmot. A European beaver (female, 11 years) had a fibroma of the gall bladder, and a golden agouti (female, 2 years) a large cell carcinoma of the lung. 6 out of 40 coypus necropsied from 1970 to 1997 revealed neoplasms: in 1977, a fibrosarcoma and a carcinoma of the lung (female, 4 years), in 1990, an adenocarcinoma of the kidney (male, 4 years), in 1993, a nephroblastoma (male, 3.5 years) and an adenoma of a sebaceous gland (male, 3 years), in 1997 a fibrosarcoma (male, 5 years) and a liver cell carcinoma (female, 4.5 years). At Berne Zoo, neoplasms (in one case a lymphosarcoma of the lung) were found in two hamsters.

Degeneration of the lens

A particular problem of viscachas at Zurich Zoo are congenital cataracts of the eye lenses. This problem, described by RÜBEL et al. in 1989, persists and is the subject of ongoing research. Lens opacity was also observed in the wild cavies living just next door to the viscachas.

Birth and rearing problems

From 1981 to 1991, there was a series of birth or rearing problems in the porcupine colony of Basel Zoo, including stillbirths after difficult parturition, cubs found dead after one day, a cub with an umbilical hernia, another one with a malformation of the forelegs, and a female that died during parturition. At Berne Zoo, perinatal deaths occurred occasionally in American beavers, capybaras, brown and mountain hares, and a brown hare and wild rabbit died during parturition. At Goldau Animals and Landscape Park, a mountain hare died of birth toxicosis. At Zurich Zoo, intrauterine asphyxia was diagnosed in wild cavies, viscachas and capybaras, cheilognathopalatoschisis in a capybara, ventricular septal defect in a wild cavy, stillbirth (without any further explanation) in wild cavies and agoutis, postnatal deaths in wild cavies, viscachas and capybaras, dystocia in a viscacha, and milk deficiency in a capybara.

Intraspecific aggression

At least 3 thirteen-striped ground squirrels, 2 prairie dogs, 2 Asian chipmunks, 3 wood mice, 3 striped grass mice, 5 porcupines, 3 agoutis, 2 capybaras and 2 chinchillas of Basel Zoo died as a result of intraspecific aggression and a few day old Asian chipmunk triplets, 1 newborn chinchilla, newborn agouti twins and 2 young brown hares were killed by their mothers. At Berne Zoo, intraspecific aggression caused the death of 2 marmots, a hamster, at least 4 Malagasy giant jumping rat, 4 gerbils, 3 porcupines, 2 coypus, a degu and 2 wild rabbits. Two more coypus and a European brown hare were killed by their mothers. During the period reviewed, bite lesions were also a problem in the beavers, wild cavies, cuis, acouchies and plains viscachas of Zurich Zoo. For earlier mortalities at Zurich Zoo, reference is made to DOLLINGER (1971).

Interspecific aggression, predation

Interspecific aggression was mostly linked to escapes. At Basel Zoo, an escaped Finlayson's squirrel was caught and eaten by a cheetah (*Acinonyx jubatus*), an escaped marmot was crushed to death by a European bison (*Bison bonasus*) bull, an escaped prairie dog fell victim to a raccoon dog (*Nyctereutes procyonoides*) while another prairie dog and a golden agouti involuntarily provided environmental enrichment to the Canadian wolves (*Canis lupus occidentalis*). A third prairie dog had to be killed after having been severely injured by brown rats (*Rattus norvegicus*). A cuis making an excursion into the neighbouring enclosure was killed and eaten by the prairie dogs and a second cuis was killed by a wild beech marten (*Martes foina*). An agouti was killed by badgers (*Meles meles*). At Berne Zoo, an American porcupine kept together with Rocky Mountain goats (*Oreamnos americanus*) was attacked and killed by one of the goats, a marmot was killed by a dog, a European brown hare by a cat, and another brown hare by a coati (*Nasua nasua*).

Discussion and conclusions

While rodents and lagomorphs were previously acquired without any concept and often placed in some more or less adequate multipurpose cages, all four zoos now keep a reduced number of species, which are kept in specifically adapted exhibits and mostly in a zoogeographic or other educational context. In all zoos, outdated enclosures for the keeping of rodents and lagomorphs have been replaced or enlarged and improved. The current facilities exceed both the minimum space requirements of the animal welfare ordinance and the recommendations of the Scientific CITES Authorities and are in the order of the much higher Swedish animal welfare standards (PEPPLER, 1992).

Association with other mammals or with birds, as is practised in all four zoos, contributes to the environmental enrichment, in particular if the species interact together, as do the tapirs and capybaras at Zurich Zoo.

From a pathological point of view, it is noteworthy that the assessment by RUEMLER (1995) that neoplasms are "extremely common" in rodents and lagomorphs, could not be confirmed in a general way as there was an accumulation of neoplasms in one population of coypus only. It should be noted that 2 of the 11 neoplasms in rodents referred to by APPLEBY & KEYMER (1971, 1973) were also found in coypus. Also the presence of strumata in two populations of coypus is interesting, as none of

the 89 strumata described by WISSER (1991) from a collective of more than 3000 necropsies concerned a rodent species.

A certain number of deaths could have been prevented if the enclosures had been escape-proof. In relation to the overall mortality this is, however, not very significant. More important are losses caused by social stress and intraspecific aggression at the time of establishing a new group or a breeding pair, or resulting from overcrowding or unsuitable composition of the groups.

Lagomorphs, and many rodents, e.g. wild cavies (JENNY, 1998) are also very susceptible to stress due to the presence of humans. This has to be taken into consideration when obtaining wild caught animals used to captive conditions, and it is always essential to provide cover such as shrubs, horizontal boards fixed slightly above head height, or overhanging rocks that are used as a retreat. These give the animals a feeling of security and enable them to monitor their surroundings (STAUFFACHER 1998). When such structures were provided for the cavies at Zurich and for the mountain hares at Berne, the animals became much more relaxed.

As shown by DOLLINGER et al. (1998), the Swiss zoos run disease prevention programmes, which include the quarantine of animals introduced into the collection regardless of their origin, the monitoring of wild rodent populations, and in three of the zoos, regular faecal and blood testings, prophylactic treatments and vaccinations also of rodents and lagomorphs. Based on the experience gained from these programmes, the following recommendations are made:

Even if there is no legal requirement, quarantines should be performed on all animals introduced in the collection and should always include examination for parasites (in lagomorphs, the Baermann funnel method should be included) and bacterial agents.

To prevent parasitoses in rodents, faeces examination of the animals in the collection should be performed at least once a year and should be repeated if problems arise, in particular if the animals are kept on substrates on which reinfestations are likely. In lagomorphs kept in naturalistic enclosures, the scheme established at Berne Zoo, i.e. testing by the sedimentation / flotation method see TENHU, 1998) at monthly intervals, should be followed, and emphasis should be laid on screening for coccidia. Sulfaquinoxaline (Sulka N ad us. vet. ® TAD) is recommended as a coccidiostaticum, and fenbendazole (Panacur ® Hoechst) for the anthelmintic treatment of lagomorphs.

Faeces should also be examined for leptospirosis, listeriosis and yersiniosis. Vaccination against leptospirosis with an inactivated vaccine is highly recommended for all susceptible animals, in particular beavers. To avoid major losses due to yersiniosis, isolate-specific vaccine should be employed once a case has been diagnosed in a group of rodents or lagomorphs. Where tuberculosis is still a problem, one should also take into account that cavies and their relatives, including capybaras (see e.g. WIESNER et al., 1997) are highly susceptible to *Mycobacterium* infections.

Since 1927, erysipelas (*Erysipelothrix rhusiopathiae*) has been known to occur in wild mice and rats (SHUMAN, 1970). In zoo rodents or lagomorphs it seems however to be of minor importance as no reference to this agent is made by GRINER (1983), RUEMLER (1995) or SCHRÖDER (1990), and as APPLEBY (1979) lists only 10 cases of Listeriosis in a total of 1295 necropsy reports. The occurrence of erysipelas in mountain hares at Berne Zoo is believed to be linked with the fact that the animals are kept together with bearded vultures. This is attractive for the public, but the permanent presence of bones and meat in the aviary does attract flies and wild rodents, and thus may increase the risk of erysipelas. Although similar problems did not occur at Goldau Wild Animals and Landscape Park, vaccination against erysipelas is recommended in such mixed exhibits. Mesh width permitting, it should also be considered associating small owls that predate on mice and voles, such as Tengmalm's (*Aegolius funereus*), pygmy (*Glaucidium passerinum*) or scops owl (*Otus scops*), with the hares and the vultures.

Other preventive measures that should be considered include the following examinations routinely performed at Zurich Zoo: blood testing of lagomorphs for *Encephalitozoon cuniculi*, faecal testing of murid rodents for lymphocytic choriomeningitis, and examination for trichophyton infections.

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Summary

Husbandry and pathology of rodents and lagomorphs in Swiss zoos

This paper provides information on rodent and lagomorph species previously or currently kept by the four scientifically directed zoos of Switzerland. Former and current enclosures are compared to the legal requirements. Information on the housing and diet of the currently kept species is given and data on breeding and survival are provided for some species. Specific pathological problems, such as infectious diseases, parasitoses, struma, neoplasms and intra- or interspecific aggression are pinpointed, and recommendations are made regarding the prevention of diseases and accidents.

Zusammenfassung

Haltung und Pathologie von Nagetieren und Hasen in schweizerischen Tiergärten

In der vorliegenden Arbeit werden die früher und derzeit in den vier wissenschaftlich geleiteten Zoos der Schweiz gehaltenen Nagetiere und Hasen vorgestellt. Ehemalige und gegenwärtige Gehege werden mit den gesetzlichen Anforderungen verglichen. Es werden Informationen über die Unterbringung und Fütterung der gegenwärtig gehaltenen Arten gegeben, und bei einigen Arten werden die Zuchterfolge analysiert. Es wird auf spezielle pathologische Probleme, wie Infektionskrankheiten, Parasitosen, Struma, Tumoren sowie zwischen- und innerartliche Aggression hingewiesen, und es werden Vorschläge zur Verhütung von Krankheiten und zur Minderung der Unfallhäufigkeit gemacht.

Résumé

Détention et pathologie des rongeurs et lagomorphes dans des parcs zoologiques suisses

Cet article présente les espèces de rongeurs et de lagomorphes détenus dans le passé et aujourd'hui par les quatre jardins zoologiques scientifiques de Suisse. L'hébergement de ces espèces dans les enclos actuels et d'autrefois est analysé par rapport aux exigences légales. Des informations concernant la détention et l'alimentation des espèces détenues à présent ainsi que le succès de reproduction y sont étudiés. Des problèmes pathologiques spécifiques tels que maladies infectieuses, parasitoses, struma, tumeurs de même que les agressions inter- et intraspécifiques sont évoqués. Des recommandations visant à prévenir les maladies et à réduire le nombre d'accidents sont apportées en conclusion.

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