

Occurrence and morphometrics of the raccoon *Procyon lotor* L. in Germany

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The raccoon (*Procyon lotor*) is distributed over the whole area of Germany. Stable populations already exist in the states of Hesse, Lower Saxony and Northrhine-Westphalia, and the species further continues to build up its inhabitation. In 13 out of the 16 states hunting of the raccoon is allowed. The body and skull of full-grown raccoons in Germany measured on average as follows (sexes separated): body weight (kg), male 5.38, female 4.62, standard body length (mm) 586 and 547, tail length 236 and 239, ear length 60 and 56, hind foot length 103 and 99, condylobasal length 110 and 106, and zygomatic breadth 72 and 67. Morphometric measurements for body and skull of the raccoon in Germany correspond to those from the American continent. In the area of introduction in 1934 in North-Hesse an accumulation of dental anomaly is observed, 32% of the skulls showing the oligodontie of the first premolar.

1. Introduction

Raccoons were introduced, i.e. released officially, in Germany in 1934, by specimens originated from the zoological garden in Hamburg. There was another release of raccoons in 1935 near Berlin without success. During the Second World War animals were freed because of lack of food, and later individual animals escaped from enclosures and fur farms. Present knowledge does not allow the identification of the subspecies of these animals. Nowadays raccoon populations exist in the states of Hesse, Northrhine-Westphalia and Lower Saxony. Reproductive populations live also in Bavaria and Thuringia near the Hessian border. Except the city states of Berlin and Hamburg there are findings of raccoons in all states in Germany (Lutz 1984, Stubbe 1990).

The purpose of this paper is to describe the present occurrence of the raccoon in Germany in more detail, present data on the morphometrics of the species and compare the German and North American raccoons in respect to body size.

2. Material and methods

Presentation on distribution is based on hunting bags, questionnaires and published information.

From 1964 until 1991 measurements were collected from 306 raccoons in two not strictly separated areas in Central Germany (50°06'–51°36'N, 8°00'–10°10'E, Table 1). Dr. Müller collected data mainly in the southeast of Hesse and neighbouring Bavaria (Area II in Table 1) over the whole period, and the present author in the northwest of Hesse and neighbouring Northrhine-Westphalia from 1977 until 1980 (Area I). Juveniles (< 1 year of age) were caught

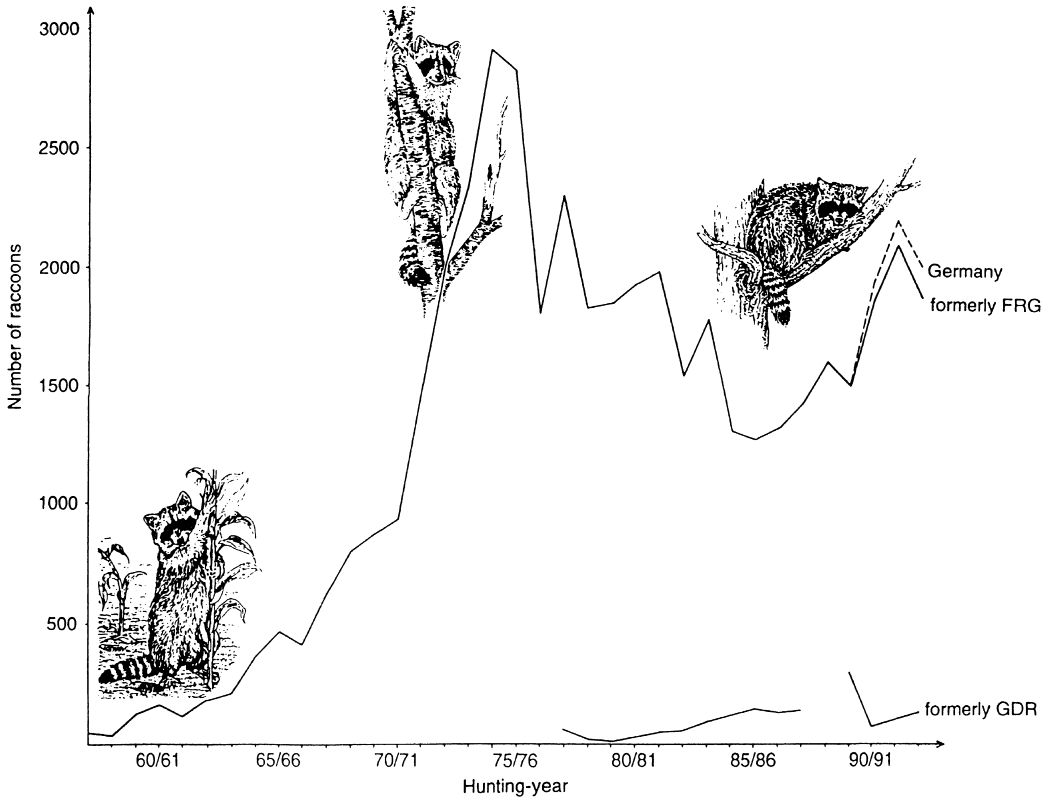


Fig. 1. Hunting bag of the raccoon in Germany (incl. specimens found dead).

throughout the year, most of them from July to November, and adults were distributed rather evenly over the whole of the year. Juveniles were sucklings and young of the year, subadults born the previous year are included into adults. The sex ratio did not differ significantly from the expected even ratio. The ratio adults to juveniles was 1:0.28 and it did not deviate significantly between the areas. Body weight was taken to the nearest gram and standard length, tail length, hindfoot length and ear length to the nearest mm. Some of these measures were used further to produce values for total length (standard length + tail length), proportion tail length

to total length, ratio hindfoot length to standard length and ratio of figure size to body weight expressed as ratio of standard length to $3\sqrt{\text{body weight}}$. Prof. Dr. König provided these statistical calculations (König et al. 1991). Skull measurements were taken according to standards at an accuracy of 0.1 mm. The skulls which were collected in the area of introduction in the northern Hessaia were examined in regard to tooth anomaly.

3. Results

3.1. Distribution and status

The raccoon is distributed over the whole of Germany, and it has further spread to all the neighbouring countries except Denmark (Lutz 1984, Stubbe 1993). Populations reproducing permanently live in the lower mountain areas in deciduous forests, with oak or beech trees and lakes, brooks and rivers.

The development of the raccoon population may be divided into three phases. After the introduction

Table 1. Age group, sex and area of origin of the present raccoon material in Germany.

		Males	Females	Total
Juvenile	Area I	20	24	44
	Area II	14	9	23
	Total	34	33	67
Adult	Area I	79	71	150
	Area II	46	43	89
	Total	125	114	239
Grand total		159	147	306

of four individuals in 1934 it was very difficult to find out what happened with these animals. The mainly nocturnal and secret life of the raccoon rendered more detailed knowledge about the development. In the second phase, since 1960, the raccoon population in the area of introduction increased rapidly and levelled off around 1975. In the third phase, a stabilisation of the population to a lower level took place (Fig. 1). Corresponding developments could be found also in some other states in Germany.

In 13 out of the 16 states of Germany the raccoon is included in the hunting law and hunting is

allowed. The species is excluded from the hunting law in the states of Baden-Württemberg, Saarland and the city state of Berlin. Table 2 gives the bag in the hunting years of 1991/92 and 1992/93; in addition to animals killed the hunting bag includes also animals found dead.

3.2. External measurements

Data on standard measurements for adult raccoons is combined from both areas and presented by sex

Table 2. Legal status of the raccoon in the hunting law, and hunting bag, including specimens found dead, in 1991/92 and 1992/93 in Germany, by state.

State	Hunting	Hunting bag	
	+ allowed – not allowed	1991/92	1992/93
Baden-Württemberg	–	?	1
Bavaria	+	147	47
Berlin	–	?	?
Brandenburg	+	17	few
Bremen	+	–	
Hamburg	+	0	0
Hessia	+	1738	1568
Lower Saxony	+	129	124
Mecklenburg-Vorpommern	+	–	1
Northrhine-Westphalia	+	183	167
Rhineland-Palatinate	+	37	6
Saarland	–	?	few
Sachsen-Anhalt	+	1	11
Saxony	+	–	3
Schleswig-Holstein	+	0	1
Thuringia	+	89	121

Table 3. Standard measurements of adult raccoons in Germany.

		Total weight (kg)	Standard length (mm)	Tail length (mm)	Hindfoot length (mm)	Ear length (mm)
Males	<i>N</i>	120	116	113	91	56
	<i>mean</i>	5.382	587	236	103	60
	<i>S.D.</i>	1.477	42.8	30.0	5.4	5.6
	<i>median</i>	5.245	590	240	103	60
Females	<i>N</i>	108	111	108	89	50
	<i>mean</i>	4.624	547	239	99	56
	<i>SD</i>	1.061	44.8	25.1	5.0	6.1
	<i>median</i>	4.55	550	240	100	56.5
<i>P (t-test)</i>		<0.001	<0.001	NS	<0.001	<0.001

(Table 3). There exists clearcut sexual dimorphism in body weight, standard length, hindfoot length and ear length, males being the larger sex. On average, females are 758 g lighter, and there is a difference of 40 mm in the standard length, 3.5 mm in the hindfoot length and 4.3 mm in the ear length. There is no sexual dimorphism in juveniles: body weight averaged 2.4 kg, standard length 427 mm and tail length 192 mm.

Regarding the total length, females are 4.6% shorter than males (Table 4). The proportion of tail length of the total length is higher for females (mean 30.4%) than for males (28.7%). The ratio

of hindfoot length to standard length is significantly higher for females (0.184) than for males (0.176). Regarding the form of the body there is no difference between males and females when expressed as ratio of standard length to $3\sqrt{\text{body weight}}$ (König et al. 1991).

In regard to the origin of the raccoon in Germany it is of interest whether the external measurements differ from those in North America. The morphometric data show that raccoons living in Germany are similar with North American raccoons in regard to form and size (Table 5). The average measurements in Germany range in the

Table 4. Calculated external measurements of adult raccoons in Germany.

		Total length (mm)	Proportion tail length of total length (%)	Ratio hindfoot length to standard length	Ratio standard length to $3\sqrt{\text{body weight}}$
Males	<i>N</i>	114	113	89	111
	mean	824	28.7	0.176	33.7
	<i>SD</i>	55	3.1	0.012	2.7
	median	827	29	0.176	33.5
Females	<i>N</i>	108	108	89	105
	mean	786	30.4	0.184	33.1
	<i>SD</i>	46	3.1	0.014	3.0
	median	795	30	0.183	32.7
<i>P</i> (<i>t</i> -test)		<0.001	<0.001	<0.001	n.s.

Table 5. Comparison of external measurements of the raccoon.

Origin	Total length (mm)	Tail length (mm)	Hindfoot length (mm)	Body weight (kg)
Canada (Banfield 1974)	846	235	112	♂ 8.6 ♀ 7.5
East-Canada (Peterson 1966)	655–960	200–275	100–125	5.4–13.6
North-America (Hall 1959)	♂ 634–950 ♀ 603–909	♂ 200–405 ♀ 192–340	♂ 96–138 ♀ 83–129	1.8–22.2
Arkansas (Sealander 1979)	603–1180	190–300	82–138	4–14
Germany, present study	♂ 824 ♀ 786	♂ 236 ♀ 239	♂ 103 ♀ 99	♂ 5.4 ♀ 4.6

middle of the ranges given for raccoons in North America (Goldman 1950, Hall 1959).

3.3. Skull measurements

The data on skull measurements originate from 25 adult male and 31 adult female raccoons in Area I. The average condylobasal length (condyli occipitales – prosthion) is 110.3 mm (range 106.0–115.4) for males and 105.5 mm (101.0–109.7) for females. The ranges for American raccoons are 94.3–125.8 for males and 89.4–115.9 for females, respectively (Goldman 1950). The zygomatic breadth averaged 71.5 mm (66.0–83.6) for males and 66.7 mm (62.4–73.1) for females, which again fall within the ranges in the material from North America (60.2–89.1 and 58.3–81.2, correspondingly; Goldman 1950).

3.4. Dental anomaly

The normal dentition of an adult raccoon is $i\ 3/3$, $c\ 1/1$, $p\ 4/4$ and $m\ 2/2$, in total 40 teeth. Goldman (1950) reports that the first premolars may be absent. In a total of 93 skulls of raccoons, which were collected near the place of introduction in Hessia, one third (32%) showed the oligodontie of P1 (Table 6). There was one skull missing all the four P1s. In one case the right lower jaw was missing P4, and in another case also the right lower jaw showed an abnormally developed M2. Extra teeth, as reported by Goldman (1950), were not found in the present material.

4. Discussion

Sixty years after the introduction of the raccoon in Germany the species has found and occupied a niche in the fauna.

During the first years after introduction in 1934 only few reports confirmed the survival of the raccoons. Later on followed a phase of considerable increase, supported by animals, which escaped or were set out especially during the Second World War. During this phase migration of raccoons over great distances was observed and soon the borders of Germany to neighbour-

Table 6. Frequency (%) of oligodontie of the first premolar in the raccoon in Hessia, Germany ($n = 93$).

	Right	Left	Both sides
Upper jaw	7.5	4.3	8.6
Lower jaw	6.5	3.2	6.5
Total 32 %			

ing countries were reached (Lutz 1984). This phase of increase was followed by a stabilisation of the population at a lower level, and it was concentrated in the region of introduction and the low mountain ranges nearby. Similar observations are reported by several authors for other mammal species after their introduction in other countries.

There are indications that the raccoon has found further favourable habitats along the migration routes and that the species is building up stable populations (Stubbe & Krapp 1993). The habitats where the raccoon lives in Germany are characterized by forests, which provide food and hides in old oaks and beeches as well as in earth dens. Additional food is available on fields with corn and fruit trees (Lutz 1981).

The morphometric data show that the raccoons in Germany are very similar with the raccoons in North America in regard to form and size (Goldman 1950, Hall 1959, Lotze & Anderson 1979, present study). The comparison with data of merriam collection confirm this.

The frequent oligodontie of the first premolar of raccoons in the area of introduction is explainable because the population was founded by only a few individuals, as the dental anomaly is surely hereditary.

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