

## Testing pulp cavity closure to estimate individual age of *Felis silvestris* (Carnivora: Felidae)

Ověřování metody měření průměru dřevné dutiny pro odhad individuálního věku kočky divoké (*Felis silvestris*) (Carnivora: Felidae)

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**Abstract.** To determine individual age of wildcat specimens in museum collections, the non-destructive method of measuring the pulp cavity closure of canines in relation to the tooth diameter was assessed. In 31 skulls of *Felis silvestris* from the collection of the University Halle-Wittenberg, Halle, Germany, the mandibles were X-rayed and the pulp cavity of the lower canines measured using ImageJ. This non destructive, relatively cheap and fast method is only applicable in young individuals of wildcats up to the age of about 10 months, but not beyond, as in later years the pulp cavity diameter does not change noticeably enough with age. To reduce measurement errors, only one observer should work on the material and isolated canines or single mandibles which can be placed flat in the X-ray chamber should be used. The study was done with a small sample only, but the limitations of the method in wildcats became apparent with the used sample already so that no more specimens were studied.

**Key words.** Age classes, ImageJ, mandibular canine, radiographs.

### INTRODUCTION

The knowledge of individual age is an important prerequisite for the research of many aspects of the animal's life history and for population studies. The study of life history can yield information on demography, ecological conditions, many aspects of biology and vulnerability of a population. "Therefore, an understanding of life history strategies is key to conservation management of endangered species" (GARCÍA-MARTÍNEZ et al. 2011: 490). However, accurate determination of an individual's age is also important for comparative craniometric studies of different geographic samples or populations. It is actually only useful to compare specimens of the same sex and similar age (VOHRALÍK 1975).

Thus the problem of exact determination of an animal's age is a long standing issue in zoology, mainly in vertebrates and particularly in mammals (see reviews by KLEVEZAL & KLEINENBERG 1969, MORRIS 1972, KLEVEZAL 1996, JOHNSTON et al. 1999). The analysis of incremental lines in tooth cement (also referred to as cementum annuli) is a widely used method (ADAMS & WATKINS 1967, MORRIS 1972, FANCY 1980, PIECHOCKI & STIEFEL 1988, JOHNSTON et al. 1999). The preparation and counting of growth lines in teeth or bone is destructive, time consuming and (relatively) expensive (POOLE et al. 1994). The costs are lower when a thin slice is cut from the root without preparing a classical thin section. To determine the age of specimens in collections, particularly

in historical material, endangered or rare species, such as the European wildcat, a non-destructive method would be desirable. Juveniles can be aged using the replacement status of the teeth (CONDÉ & SCHAUBENBERG 1978, PIECHOCKI & STIEFEL 1988, GARCÍA-PÉREA et al. 1996). Ontogenetic changes in skull measurements and morphology are also well known (e. g. KRATOCHVÍL 1973, GARCÍA-PÉREA et al. 1996). These indicate relative age, and enable grouping in rough age classes, but are not useful to determine the exact age. No linear cranial measurement was found useful to reliably determine the age of a wildcat skull (STEFEN & HEIDECKE 2011).

Measuring the percentage of pulp cavity closure (PCC) in canine teeth has been used as a non-destructive method (using radiographs) to determine the age of individuals. PCC is considered useful in juvenile individuals (MORRIS 1972) and to distinguish the juveniles of the year (GRUE & JENSEN 1976). The pulp cavity closes with age as secondary dentine is deposited more or less evenly (GUSTAVSON 1950, WOODS et al. 1990, DRUSINI et al. 1997, LANDON et al. 1998, JOHNSTON et al. 1999). In some cases, like in coyotes, this method appears sufficiently exact in comparison to incremental lines of cement (BINDER et al. 2002). However, in the Iberian lynx, ZAPATA et al. (1997: 122) found that for adults the most accurate method was using incremental lines of the cementum. Measuring of pulp cavity closure in radiographs is relatively cheap (if a digital X-ray apparatus is available), relatively fast, and non destructive.

The PCC method is applied here to a sample of European wildcats to test its efficiency in this species. The procedure in the study was selected in order to address several questions: How strongly is the measurement of the pulp cavity influenced by the angle of the X-ray beam? Can measurements at isolated canines, single and complete mandibles be compared? Only if this is possible, the method can be used without any destructive action. And how big is the difference between observers?

## MATERIAL AND METHODS

In total 31 wildcat (*Felis silvestris* Schreber, 1777) skulls with deciduous canines, originating from the wider area of the Harz Mountains, Saxony-Anhalt and Thuringia, Germany, deposited in the Central Repository for Natural Science Collections of the University Halle-Wittenberg, Halle, Germany, were studied. The age data were taken from the museum records. Most had been determined using the incremental lines of teeth (published by PIECHOCKI & STIEFEL 1988, see Table 1). The material ranged in age from 4 to 66 months. In wildcats, canines erupt at the age of 108–123 days (3.6–4.1 months) in females and at the age of 122–141 days (4.1–4.7 months) in males (CONDÉ & SCHAUBENBERG 1978). The lower canines were selected. As the aim of this study was to evaluate whether the determination of pulp cavity closure can be used as a totally non-destructive and relatively fast method to age the individuals, the canines were not extracted, neither were the mandibles detached if they were still fused. Such a procedure was possible for all collection material, while any changes such as tooth extraction would be possible with permit only. This approach results in: isolated canines or isolated mandibles, which could both be placed clearly flat in the X-ray chamber of the machine, and complete mandibles. Images of isolated lower canines were taken at different angles (in lingual-buccal direction and mesial-distal direction) to see how different the pulp cavity appears and how the X-ray angle influences the measurements (Fig. 1). Similarly, for complete mandibles, different positions resulting in varying X-ray angles were also tested.

The X-ray photos were taken with a Faxitron LX 20 (Faxutrib X-ray LLC, Lincolnshire, Illinois, USA) and X-ray dosages of 18 kV to 50 kV were tested with an exposure time of 16 seconds. The best results were obtained with 35–40 kV. A metal screw nut of known inner diameter (3.4 mm) was used for size calibration of the photos. The photos were scaled in ImageJ (<http://rsb.info.nih.gov/ij/index.html>; SCHNEIDER et al. 2012) and the diameter of the canine pulp cavity (Dp) and the diameter across the canine (Dc) were measured below the tooth crown (BINDER et al. 2002: Fig. 1). Measurements were taken as perpendicular to the pulp cavity as possible and the reference was the more curved side of the canine (Fig. 1).

Table 1. Averaged measurements for each studied individual.

Tab. 1. Průměrné hodnoty rozměrů jednotlivých měřených jedinců.

Abbreviations / zkratky: collno – collection number (Central Repository of the University in Halle, Germany / sbírkové číslo (ústřední depositář Univeristy v Halle, Německo); Ob – observer / pozorovatel: S – student / student, others – author / ostatní – autorka; No – number given in the table by PIECHOCKI & STIEFEL (1988) / číslo udávané v tabulce PIECHOCKIHO & STIEFELA (1988); AP – age class following PIECHOCKI & STIEFEL (1988) / věková třída podle PIECHOCKIHO & STIEFELA (1988); A – age in months / věk v měsících; X – sex / pohlaví; NM – number of measurements / počet měření; Dc – diameter of canine / průměr špičáku; SD – standard deviation / směrodatná odchylka; Dp – diameter of pulp cavity / průměr dřevové dutiny; %Dp – percentage of pulp cavity closure / procentuální poměr uzavření dřevové dutiny; type / typ preparátu: ism – isolated right or left mandible / izolovaná levá nebo pravá polovina dolní čelisti; cm – both mandibles together / obě části dolní čelisti společně; isc – isolated canine / izolovaný špičák, sk – skull / lebka

collno	Ob	No	AP	A	X	NM	Dc	SD	Dp	SD	%Dp	SD	logDc	logDp	type
84/116		67	juv	4	f	8	5.144	0.091	4.619	0.087	10.824	1.171	0.711	0.663	isc
75/300		29	juv	4.5	m	22	5.068	0.266	4.066	0.213	19.721	2.668	0.704	0.609	ism
52/1330	S	13	juv	6	f		4.089		2.243		45.100		0.612	0.351	cm
78/304		39	juv	6	m	20	5.075	0.384	3.813	0.436	25.055	3.501	0.704	0.579	cm
81/100		61	juv	6	m	12	4.724	0.173	2.478	0.330	47.459	7.244	0.674	0.390	cm
57/1048			imm	7	f	6	3.388	0.249	1.222	0.174	64.015	3.427	0.529	0.008	isc
84/9			imm	7	m	12	4.494	0.193	3.103	0.271	31.049	3.276	0.652	0.490	cm
86/47		87	imm	7	f	9	5.321	0.140	2.740	0.141	48.474	3.099	0.727	0.437	isc
79/044	S		imm	8	f		4.458		1.703		61.800		0.649	0.231	ism
79/54			imm	8	f	12	3.491	0.109	0.695	0.043	80.099	0.906	0.543	-0.159	cm
56/183		4	imm	8	m	15	4.499	0.566	2.229	0.309	62.448	6.513	0.650	0.344	ism
79/055	S	44	imm	8	m		5.088		2.835		44.300		0.707	0.453	cm
79/37		41	imm	10	m	20	4.598	0.173	0.862	0.223	81.123	5.195	0.662	-0.882	cm
84/16		66	imm	10	m	9	4.704	0.216	2.441	0.117	47.972	4.155	0.672	0.387	cm
79/150		48	sad	14	m	9	5.089	0.193	1.390	0.062	72.674	1.126	0.763	0.143	ism
79/235		51	sad	14	m	24	4.583	0.167	0.834	0.188	83.245	6.462	0.661	-0.091	cm
78/275	S		sad	15	m		4.835		1.109		77.100		0.684	0.045	cm
76/426		31	sad	16	f	6	4.668		1.399	0.076	69.945	2.029	0.669	0.140	sk
63/735		19	sad	17	f	24	3.680	0.366	0.762		79.214		0.564	-0.120	cm
59/952	S	5	sad	18	m		4.170		0.997	0.046	76.100	1.954	0.620	-0.001	ism
80/53			sad	20	m	13	4.882	0.353	0.953	0.055	80.537	1.393	0.688	-0.021	cm
85/167		84	sad	20	m	12	4.945	0.242	1.057	0.078	78.592	1.220	0.694	0.024	isc
54/1211		1	ad	30	m	11	4.534	0.398	0.851	0.146	81.183	3.943	0.655	-0.072	ism
80/1			ad	36	m	12	4.988	0.309	0.832		83.143		0.697	-0.085	cm
85/168	S	85	ad	36	m		4.945		0.915	0.049	81.500	2.079	0.694	-0.039	cm
70/396	S	9	ad	36	m		4.775		0.775		83.800		0.679	-0.111	cm
70/396						4	4.45	0.058	0.668	0.047	85.029	0.983			
79/25		40	ad	42	f	6	4.108	0.219	0.816	0.033	80.046	1.129	0.613	-0.089	ism
79/239		52	ad	48	m	8	4.958	0.269	0.886	0.046	82.095	1.151	0.695	-0.053	isc
79/59		47	ad	48	m	9	4.738	0.295	1.053		77.727		0.675	0.022	ism
from 1942			adult	60	?	3	3.537		0.666		81.190		0.548	-0.177	sk
70/191	S	11	ad	66	m		4.995		1.186		76.300		0.699	0.074	ism
70/191						4	4.652	0.113	0.862	0.018	80.939	0.711			



Fig. 1. X-ray photographs of two isolated lower canines of wildcats (*Felis silvestris*) in two different angles; A, B – Halle 56/183, ♂, 8 months old; C, D – Halle 79/239, ♂, 48 months old. Scale bar = 6 mm. The lines indicate where the measurements of the pulp cavity (black line) and tooth diameter (white line) were taken.

Obr. 1. Roentgenové snímky dvou izolovaných dolních špičáků kočky divoké (*Felis silvestris*) pod dvěma různými úhly; A, B – Halle 56/183, ♂, 8 měsíců stár; C, D – Halle 79/239, ♂, 48 měsíců stár. Měřítko = 6 mm. Čáry ukazují úroveň měření rozměru dřeňové dutiny (černá) a průměru zubu (bílá).

Table 2. Measurements of the two isolated canines in the lingual-buccal (ling-bucc) and mesio-distal (mes-dist) directions. Mean and standard deviation are given.

Tab. 2. Rozměry dvou izolovaných špičáků ve směru lingualně-buccálním (ling-bucc) a mesio-distálním (mes-dist); uveden je průměr a směrodatná odchylka.

Abbreviations / zkratky: collno – collection number (Central Repository of the University in Halle, Germany) / sbírkové číslo (ústřední depositář Univeristy v Halle, Německo); age – age in months / věk v měsících; n – number of measurements / počet měření; Dp – diameter of pulp cavity / průměr dřeňové dutiny; %Dp – percentage of pulp cavity closure / procentuální poměr uzavření dřeňové dutiny

collno	age	Dp ling-bucc	%Dp ling-bucc	Dp mes-dist	% Dp mes-dist
56/183	8	1.689±0.029 (n=12)	47.75±2.91 (n=12)	1.335±0.014 (n=8)	51.40±2.94 (n=8)
79/239	48	1.957±0.038 (n=13)	84.16±0.94 (n=13)	1.501±0.024 (n=12)	77.62±1.33 (n=12)

To evaluate the method, it appeared useful to test the variability of measurements taken by a single observer. Therefore, several measurements were taken on each photograph of each canine. For complete mandibles, the measurements of both canines were considered. And several photographs (differing in kV and in case of complete mandibles differing in X-ray angle) were used. This resulted in 4–20 measurements per tooth (Table 1). This procedure was performed for 23 specimens. For 8 specimens only one picture and the measurements taken by a student intern were used. In two cases the measurements were repeated and directly compared, the others were used for a general comparison between observers.

The percentage of pulp cavity closure (% Dp) was calculated using the formula:  $\% Dp = 100 \times (Dc - Dp) / Dp$ , with Dc – diameter of canine, Dp – diameter of pulp cavity (MEACHEN-SAMUELS & BINDER 2010). The means, standard deviations and logarithms to the basis 10 (log) were all calculated with Excel 2007. Logarithms are used to reduce skewness towards large values and a log-log scale usually helps to depict a linear relationship. For complete mandibles, the measurements (Dc, Dp, Dc – Dp and % Dp) of the two canines analyzed with a different X-ray angle were compared using the student's T-test at the 95% level of significance. In case of unequal variances, the nonparametric Mann-Whitney U test was used. All analyses were done using SPSS 14.

## RESULTS

The Dp values varied for both isolated canines with the angle they were X-rayed in (Table 2, Fig. 2). The Dp values and % Dp varied more in older individuals with a different X-ray angle: Dp 0.35  $\mu\text{m}$ , % Dp 3.65 in the four month old and Dp 0.456  $\mu\text{m}$  and % Dp 6.54 in the 48 month old individual. This is contrary to the impression from plotting of the measurements (Fig. 2). The % Dp over the two positions in the X-ray ranges between 12.49% in 56/183 and 10.21% in 79/239. This is in the range of some other single canines of complete mandibles of other specimens (e.g. 79/37 sin, 78/304 dext, 79/235 dext). The summarized measurements for all

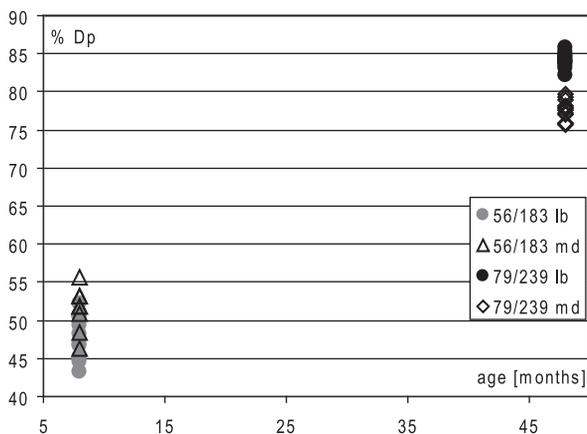


Fig. 2. Scatter diagram of the measurements of % Dp of the two isolated canines as in Fig. 1: A, B – Halle 56/183, ♂, 8 months old; C, D – Halle 79/239, ♂, 48 months old, positioned in the lingual-buccal (lb) or mesio-distal (md) directions in the X-ray chamber.

Obr. 2. Vztah rozměrů (% Dp) dvou izolovaných špičáků jako na obr. 1: A, B – Halle 56/183, ♂, 8 měsíců stár; C, D – Halle 79/239, ♂, 48 měsíců stár, natočený v roentgenové komoře do směru do lingualně-buccálního (lb) nebo mesio-distálního (md).

Table 3. Summary of the measurements for complete mandibles (mc) and one skull (sk) to compare the canines X-rayed at different angles.

Tab. 3. Přehled rozměrů Summary of the measurements for complete mandibles (mc) and one skull (sk) to compare the canines X-rayed at different angles.

Abbreviations / zkratky: collno – collection number (Central Repository of the University in Halle, Germany) / sbírkové číslo (ústřední depositář Univeristy v Halle, Německo); dext – right / pravý; sin – left / levý; type / typ preparátu: cm – both mandibles together / obě části dolní čelisti společně; sk – skull / lebka; NM – number of measurements / počet měření; Dc – diameter of canine / průměr špičáku; % Dp – percentage of pulp cavity closure / procentuální poměr uzavření dřevové dutiny, SD – standard deviation / směrodatná odchylka; diff dext sin – statistical difference between the measurements of the right and left canine / statistický rozdíl mezi rozměry pravé a levé poloviny dolní čelisti; † only one tooth measured / měřen jen jeden zub; # few measurements only / jen něco rozměrů; \* one tooth visible in X-ray only / jen jeden zub patrný na roentgenovém snímku

collno	type	age	NM	Dc	Dp	SD Dp	%Dp	SD %Dp	diff dext sin
78/304 all	cm	6	20	5.075	3.813	0.436	25.05	3.501	no diff
78/304 dext		6	10	5.268	4.009	0.318	24.00	2.804	
78/304 sin		6	10	4.882	4.617	0.464	26.11	3.944	
81/100 all	cm	6	12	4.724	2.478	0.330	47.46	7.244	no diff
81/100 dext		6	6	4.721	2.662	0.076	43.56	2.760	
81/100 sin		6	6	4.727	2.294	0.392	51.36	8.474	
84/9 all	cm	7	12	4.494	3.103	0.291	31.05	3.276	Dp var uneq Dc-Dp, %Dp diff Dc-Dp, %Dp diff
84/9 dext		7	6	4.580	3.254	0.304	29.08	3.317	
84/9 sin		7	6	4.408	2.953	0.126	33.02	1.771	
79/54 all	cm	8	12	3.491	0.695	0.042	80.10	0.906	no diff
79/54 dext			6	3.443	0.688	0.026	80.01	0.881	
79/54 sin			6	3.539	0.702	0.047	80.19	1.005	
79/37 all	cm	10	20	4.598	0.862	0.223	81.12	5.195	all diff
79/37 dext			10	4.502	1.011	0.064	77.56	1.243	
79/37 sin			10	4.740	0.640	0.187	86.47	4.049	
84/16 all	cm	10	9	4.704	2.441	0.117	47.97	4.155	no diff
84/16 dext		10	6	4.770	2.409	0.122	49.32	4.526	
84/16 sin		10	3	4.580	2.505	0.093	45.27	1.161	
79/235 all	cm	14	24	4.583	0.834	0.188	83.25	6.462	Dc-Dp diff
79/235 dext		14	11	4.482	0.857	0.124	82.39	6.235	
79/235 sin		14	12	4.685	0.811	0.240	84.10	6.844	
76/426 all	†cm	16	6	4.668	1.399	0.252	69.94	5.942	
63/735 all	cm	17	11	3.680	0.762	0.762	79.21	2.029	all diff
63/735 dext			7	3.933	0.793	0.051	79.82	1.157	
63/735 sin			6	3.215	0.689	0.078	78.56	2.467	
80/53 all	cm	20	12	4.882	0.950	0.046	80.54	1.954	Dc-Dp, %Dp diff
80/53 dext		20	4	4.608	0.961	0.033	79.13	0.904	
80/53 sin		20	8	5.019	0.936	0.052	81.24	1.987	
80/1 all	#cm	36	6	4.988	0.832	0.146	83.14	3.943	Dc-Dp, %Dp diff
from 1942 all	*sk	60	2	3.537	0.666		81.19		

individuals are given in Table 3 and illustrated in Fig. 3. Isolated canines and single mandibles showed the lowest variability and measurement error for % Dp, about 3–5%. Measurements of

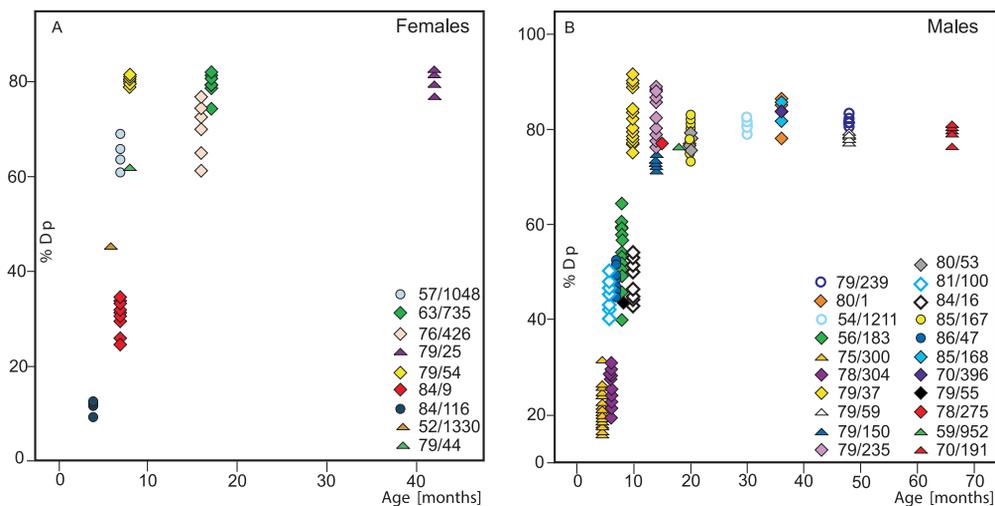


Fig. 3. Scatter plots of the percentage of pulp cavity closure (% Dp) in the studied specimens against the age of the respective individuals in months. A – females; B – males. Circles indicate isolated canines, triangles isolated mandibles and diamonds complete mandibles.

Obr. 3. Vztah procentuálního poměru uzávěru dřevné dutiny (% Dp) u studovaných jedinců a jejich věku v měsících. A – samice; B – samci. Kroužky představují izolované špičáky, trojúhelníky rozdělené poloviny dolních čelisti a kosočtverce úplně dolní čelisti.

both canines of complete mandibles varied much more. In females and males there is a clear increase in % Dp, as well as Dp, with age, up to about 10 months. With further increase in age, % Dp stays about the same, around 80% (Fig. 3). But even for the individuals up to 10 months in age it is difficult to draw a clear line to be used as a calibration curve, even in the logarithmic scale (Fig. 4). The variability in the measurements taken by one observer is clearly visible and thus indicates an uncertainty in single measurements such as those carried out by the student. Differences between observers is indicated with 1.8% in one specimen (Table 1). In the overall picture, however, these values are within the range of the other measurements taken repeatedly. Thus, there is an error rate of a single observer and between observers, but both seem to be of a similar range.

The results indicate that % Dp as well as the direct measurement of pulp cavity can be useful to estimate the age of wildcats up to about 10 months old. After that the pulp cavity appears to stay stable, at least up to the age of 66 months (the oldest individuals in the study). The best results, a small range of values with repeated measurements, can be obtained with isolated canines or at single mandibles.

## DISCUSSION

The pulp cavity closure can be determined with non-destructive methods, but the results show that the mandibles should be detached to reduce the measurement error. This would still be destructive, but the symphysis is clearly defined and isolated mandibles can well be glued

together again – given the permit to do so from the relevant authority in case of museum specimens. However, the main drawback of the PCC method is the rapid closure of the pulp cavity to a level where it does not change noticeably enough with further age. Thus, only individuals

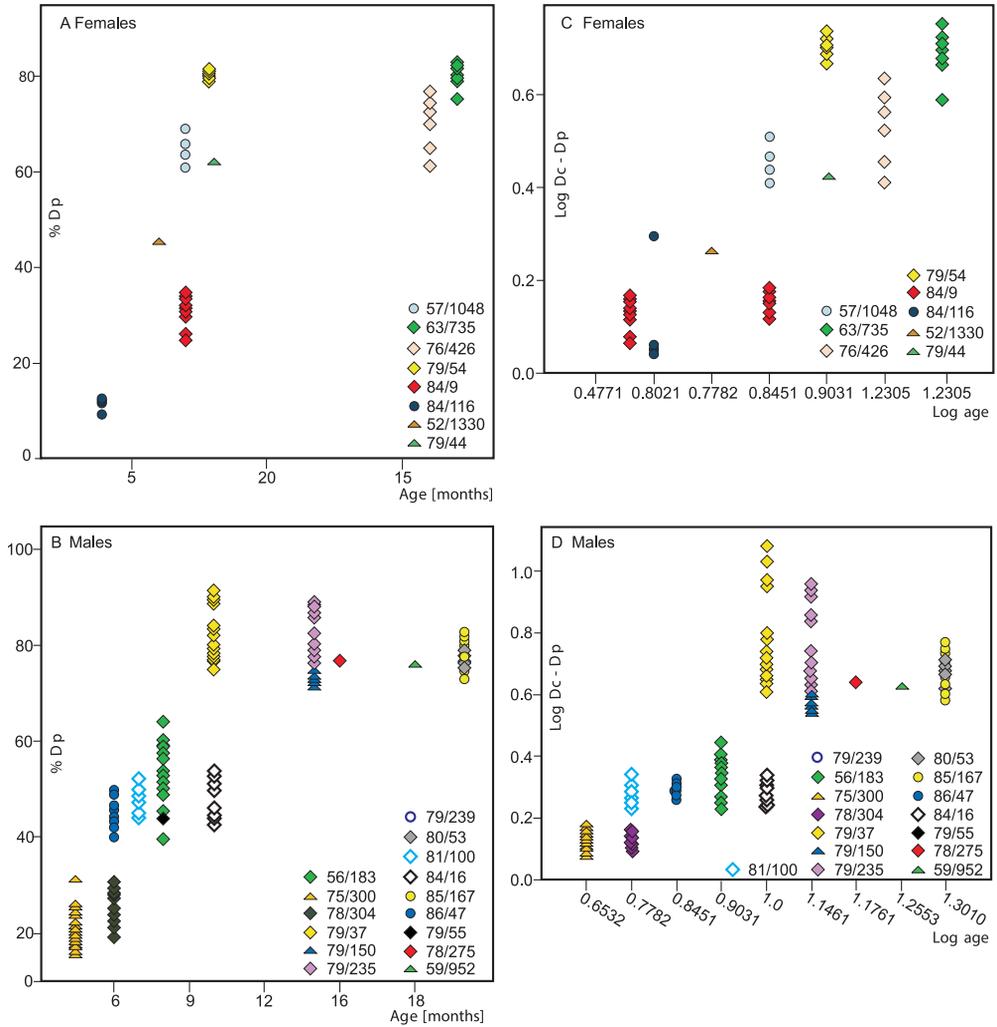


Fig. 4. Scatter plots of the percentage of pulp cavity closure (% Dp, A, B) and log Dc–Dp (C, D) for individuals aged up to 20 months. A – % Dp for females; B – % Dp for males; C – log Dc–Dp for females; D – log Dc–Dp for males. Symbols as in Fig. 3.

Obr. 4. Vztah procentuální poměru uzávěru dřevové dutiny (% Dp, A, B) a logaritmu Dc–Dp (C, D) pro jedince s určeným stářím do 20 měsíců. A – % Dp samic; B – % Dp samců; C – log Dc–Dp samic; D – log Dc–Dp samců. Symboly jako v obr. 3.

up to 10 months or about a year of age can be distinguished from older ones. The method is not useful to age adult wildcats.

As the increase of % Dp is very steep with the first months of age, and the studied specimens show a range of measurements, a clear and exact age determination is difficult even up to the age of about 10 months.

A general and great drawback of the method is where and how to exactly and reproducibly place the measurements. MEACHEN-SAMUELS & BINDER (2010: 272) indicated that the “measurements were taken perpendicular to tooth height at the point where the tooth emerges from the alveolus at its widest” (see BINDER et al. 2002: Fig. 1). In this description, several details remain unclear, however. Due to the curvature of the canine, the right angle is difficult to determine. The rim of the alveole is not useful in isolated canines, and canines of several carnivore species are pushed continuously from the alveole, altering the position of the tooth within the alveole with age. Here we tried to use the end of the crown as an indicator of the site for measurements. Measuring both lower canines (with different X-ray angles) of the same specimen gave similar results in some individuals, but also some bigger differences were visible (Fig. 3).

The closure of pulp cavity has been considered “a reasonable predictor of relative age in carnivores.” (BINDER et al. 2002). Pulp cavity closure stops at an earlier age than usual death occurs. For several species this age has been determined as follows: around seven years in gray wolves (LANDON et al., 1998), about eight years in lions (SMUTS et al. 1978). In coyotes KNOWLTON & WHITTEMORE (2001: Fig. 3) found the pulp cavity to change up to an age of about 60 months. For the medium sized cat *Lynx pardalis* the limit seems to be four years (ZAPATA et al. 1997: Fig. 2). MORRIS (1972) and GRUE & JENSEN (1976) already indicated that the size of pulp cavity or percentage of its closure may only enable a differentiation between juvenile and adult individuals. This is generally supported here; PCC works for wildcats up to an age of about 10 months, i.e. about a year. The permanent dentition is complete at about seven months (175–180 days in females and 190–195 days in males (CONDÉ & SCHAUENBERG 1978, PIECHOCKI & STIEFEL 1988, GARCÍA-PEREA et al. 1996)). Sexual maturity is reached in females at about 12 months and in males at about 9–10 months (CONDÉ & SCHAUENBERG 1969). The epiphyses close at 18–20 months in males (PIECHOCKI & STIEFEL 1988). Thus the closure of pulp cavity to a more or less constant level occurs about contemporaneously to sexual maturity in wildcats.

The study includes only a relatively small sample, but the major constraints become apparent and would not be negligible with a much larger sample. It can be concluded that for wildcats the non-destructive method of measuring Dp or % Dp is only useful to estimate the age of individuals maximally up to an age of about 10 months. This alone, however, is not enough to assess the age structure of populations or regional samples of wildcats. For more accurate age determination, the more time consuming and destructive method of counting the incremental lines of the cementum of canines is more reliable as stated for Iberian lynxes (ZAPATA et al. 1997). This might, however, not be an applicable method (due to destructiveness, high time demands and costs POOLE et al. 1994) in all studies.

## SOUHRN

Pro zjištění možnosti určení individuálního věku jedinců zoologické sbírky byla ověřována metoda měření uzavěru dřevné dutiny ve špičácích ve vztahu k průměru zubu. Dolní čelisti 31 lebek kočky divoké (*Felis silvestris*) ze sbírky University Halle-Wittenberg v Německu byly roentgenovány a s pomocí programu ImageJ byla měřena dřevná dutina dolních špičáků. Tato nedestruktivní a poměrně levná metoda je použitelná u mladých jedinců kočky divoké jen do stáří 10 měsíců, ale ne výše, neboť v pozdějším věku

se průměr dřevné dutiny významněji nemění. Pro zamezení chyb v měření je ovšem nutné, aby měření prováděla jedna osoba a na materiálu rozdělných čelistí anebo přímo izolovaných zubů, které lze umístit na plochu do roentgenové komory. Tato testovací studie byla prováděna jen na malém počtu jedinců, ovšem zjevné omezení této metody pro použití u divokých koček se zdá být jasně patrné z již použitého materiálu.

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