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Age determination in the Red Fox (*Vulpes vulpes*): a comparative study

Určování věku u lišky obecné (*Vulpes vulpes*): srovnávací studie

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Abstract. The paper summarises the results of comparing several non-metric methods of age determination in the red fox, based on skull material. The methods under comparison include examination of tooth wear (M^1) and occlusion of selected cranial sutures (*os basioccipitale-os basisphenoidale*, *os praesphenoidale-os basisphenoidale*, and *sutura maxilloincisiva*), the size of the longitudinal fissure on the crowns of canines, and the number of increment layers of secondary dental cement. The wear of M^1 shows rather great individual differences ranging up to two years from the actual age of the individual under study. As regards the cranial sutures under study, juvenile individuals can be differentiated from subadult (largely yearling) ones by the time sequence of the occlusion between *os basioccipitale* and *os basisphenoidale*. The interval between the occlusion of *os praesphenoidale* and *os basisphenoidale* permits a rather reliably to differentiate between foxes 1 to 1.5 years old and those 2 to 2.5 years old (naturally, using the theoretical birth and death dates). The process of occluding dental pulp can be followed up by the presence and size of the longitudinal fissure on canines, which arises as an artefact due to the drying up of prepared skulls; using that clue, one can determine the age of a fox between two and three years. A tentative tool has been compiled by which to estimate the approximate age of red foxes up to two years of age by using external characters on their skulls and dentition. The age of older individuals can be estimated by counting the increment layers of dental cement on longitudinal ground preparations of dental roots (preferably canines). In the material of the red fox skulls obtained from various places in the Czech Republic roughly a half were individuals less than one year old (♂♂ 53%, ♀♀ 50%), two-year-old foxes accounted for roughly one third (♂♂ and ♀♀ 29% each), and the remaining 20% or so comprised individuals older than two years. The mean age of the red fox sample under study is 17.9 months (♂♂ 18.1, ♀♀ 17.7 months); the oldest individual (a ♀) was estimated to have been 95 months of age.

INTRODUCTION

The red fox (*Vulpes vulpes*), most common medium-sized carnivore in the Czech Republic (the present annual bags varying between 60 and 90 thousand foxes; Červený et al. 2004) is an important element in various ecosystems including the suburban and urban environments of town agglomerations. In contrast with this fact is present insufficient knowledge of the biology and ecology of the Czech red fox populations. Not including various faunal reports (cf. Heráň & Sládek 1970, Anděra & Hanzal 1996), bibliography comprises just a few scattered reports aimed mostly on the red fox parasites and rabies (Prokopič 1960, Červený et al. 2000, Matouch 2000, Martínek et al. 2001) or food analyses (Kožená 1988) and dental anomalies (Heráň 1987,

Honzírek 2004). For instance, no data are available on age structure, being the basic parameter of population studies.

A large number of authors reported on the age determination in the red fox (and canids in general), using various criteria, such as body weight and dimensions (Lindström 1983, Stubbe 1989, Wandeler & Lüps 1993), weight and length of baculum (van Bree et al. 1966, 1978, Harris 1978, Nelson & Chapman 1982, Wandeler & Lups 1993, Zapata et al. 1995), lens dry weight (van Haaften 1970, Phillips 1970, Harris 1978, Nelson & Chapman 1982, Cavallini & Santini 1995a, Zapata et al. 1995), process of occlusion of cranial sutures (Churcher 1960, Harris 1978, Zapata et al. 1995), development of sagittal crest (Podhájský 1930, Harris 1978, Ansorge 1994), cranial dimensions (Huson & Page 1980, Nelson & Chapman 1982), degree of tooth wear (van Bree et al. 1974, Harris 1978, Stubbe 1989, Zapata et al. 1995), occlusion of dental pulp (Harris 1978, Goszczynski 1989, Cavallini & Santini 1995a, Zapata et al. 1995), or increment layers of secondary dental cement (van Bree et al. 1974, Harris 1978, Driscoll et al. 1985, Klevezal & Klejnenberg 1967) and dental cement (Klejnenberg & Klevezal 1966, Grue & Jensen 1973, Harris 1978, Nelson & Chapman 1982, Cavallini & Santini 1995a, Zapata et al. 1995).

The aim of the present study is to compare several non-metric procedures in determining the age of red fox on the basis of cranial (or, as the case may be, dental) material, to estimate the degree of their time consumption as well as reliability, and finally compile tentative directions for estimating the age of individual foxes in different age categories.

MATERIAL AND METHODS

The study was based on material of 344 red fox (*Vulpes vulpes*) skulls kept in the collections of the Department of Zoology, National Museum in Prague. Most of the specimens were killed in various parts of the Czech Republic in 1995–2004 and sent to the State Veterinary Institute in Liberec-Vratislavice nad Nisou to be examined for the presence of rabies. Only the skulls of negative specimens were prepared to be used in this study. Besides, there was a small series of occasional kills or finds of dead foxes in the hunting grounds of the Czech and Moravian Hunters Union in various regions, predominantly in SW Bohemia. The data of kill, locality and mostly also sex were available for all specimens (in all, 208 ♂♂, 127 ♀♀, and 9 specimens of unknown sex). Their age was determined by means of a combination of four non-metric characters: degree of tooth wear, occlusion of selected cranial sutures, size of longitudinal fissure on canine crowns, and number of increment layers of secondary dental cement. Invariably the age was determined to the nearest half a month for specimens less than one year of age, and to the nearest month for those older than one year. The final age determination was based on the known date of death of each specimen, and the theoretical birth date of all specimens. The latter was appointed as April 1st on the basis of the reproduction cycle of red fox (Ansorge 1990, Cavallini & Santini 1995b) and taking into consideration the geographic position of the Czech Republic (Jirásek 2004, J. Červený pers. comm.). Even though in this country the young may exceptionally be born as early as mid-February (Jelínek 2005), most young are born in late March to early April, and thus the arbitrary date appears to be most suitable.

RESULTS AND DISCUSSIONS

Tooth wear

Most authors recommend to study the wear of the upper first molar (van Bree et al. 1974, Stubbe 1989) or the upper incisives (Harris 1978, Zapata et al. 1995). In the present study, attention was paid to the wear of the first upper molar M^1 (Fig. 1) and its correlation with age determined by the number of increment layers of secondary dental cement.

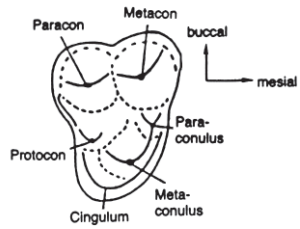

Fig. 1. Description of the first upper molar – M^1 (from Wandeler & Lüps 1993).
Obr. 1. Popis prvního horního moláru – M^1 (podle Wandelera & Lüpse 1993).

Even if the initial sings of weakly worn first M^1 conule (most frequently the metaconule) can be observed in young foxes as early as 7 months of age, the presence of absolutely intact molars (in 90% of specimens) is typical of the age group up to 8 months. Quite rarely a very slight wear of two molar conules (mostly the metaconule and paracone or protocone) may occur at around 8 to 9 months of age.

At the age of 8.5–12 months the frequency of occurrence of intact molars decreases to 62% (in specimens between 8.5 and 10 months of age) and down to 40% (in specimens between

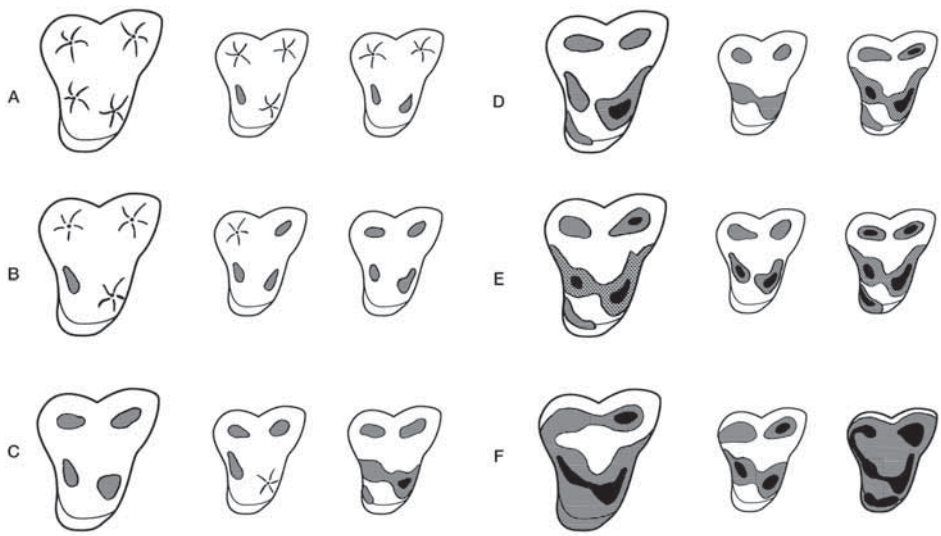

Fig. 2. Scheme showing the degree of wear of M^1 in Red fox in dependence on age (emphasizing the most typical shape of wear, besides examples of wear variation in a given age): A, up to 1 year of age; B, 1–2 years; C, 2–3 years; D, 3–4 years; E, 4–5 years; F, older than 5 years.
Obr. 2. Schematické znázornění stupně opotřebení prvního horního moláru (M^1) u lišky obecné podle věku (u všech zvýrazněn nejtypičtější tvar obrusu, vedle pak příklady variability obrusu pro daný věk): A do 1 roku, B 1–2 roky, C 2–3 roky, D 3–4 roky, E 4–5 let, F více než 5 let.

10.5 and 12 months of age). Worn teeth predominantly show a weak wear of metaconule (23% of specimens), other wear patterns occurring more rarely (e.g. on paracone, metacone or protocone), or affecting two conules at the same time (Fig. 2A).

Metaconule wear is the most frequent tooth wear pattern in the second year of life (23%), followed by wear patterns of metaconule + protocone, or metacone + protocone + paracone (21% each), and there also occur patterns in which the wear affects a combination of two or three conules (more rarely of all four main cusps). A quite intact molar was only recorded in 5% of specimens, the oldest one being 19 months of age (Fig. 2B).

The third year of life is characterised by heavier wear of all 4 main cusps (36% of specimens) or, exceptionally, 2 or 3 cusps. There also occur a weak wear of cingulum (in its initial phase on the side below metaconule) and the first dark spots on free dentine (again most frequently on metaconule). In some cases the wear of the metaconule and protocone is so considerable that the two worn parts fuse to form a "spectacled pattern" (Fig. 2C).

The fourth year of life is characterised by dark spots on one to three heavily worn cusps, the wear of a part of cingulum, and the presence of the "spectacled pattern" (Fig. 2D).

During the fifth year of life the "spectacled pattern" increases in size, the dark spots become larger and more numerous yet they still occur in the places of heavily worn cusps or cingulum (Fig. 2E).

Specimens more than five years of age already show heavily worn first upper molars, all their cusps being considerably worn, the same as cingulum, the wear pattern forming large and variously fused blotches (for example, even a „spectacled pattern" in the places of paracone

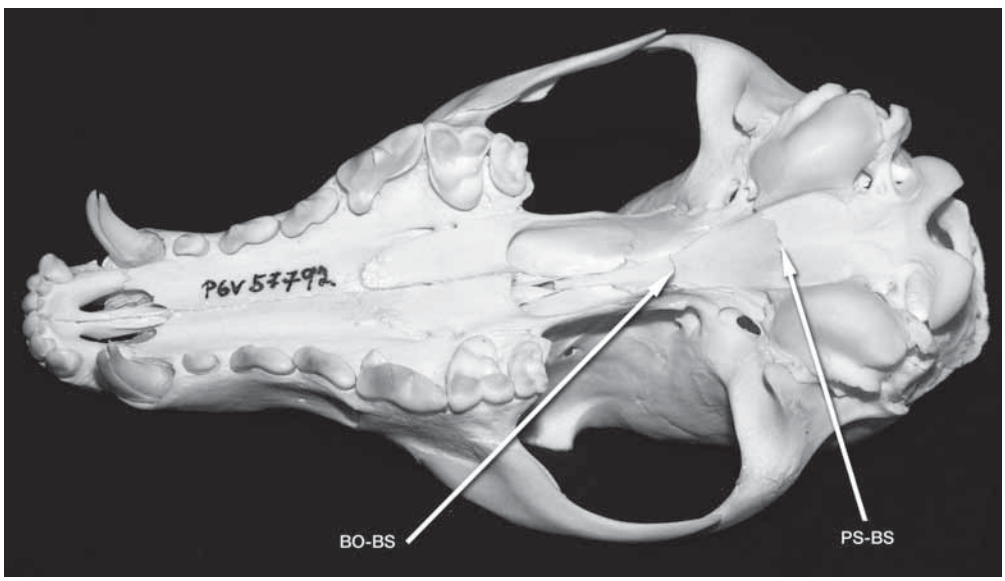

Fig. 3. Cranial sutures under study (1) BO-BS and PS-BS (from Zapata et al. 1995) (photo by M. Hrdý).
Obr. 3. Sledované lebeční švy (1) BO-BS a PS-BS (podle Zapaty et al. 1995) (foto M. Hrdý).

Table 1. Occlusion of cranial suture BO-BS in Red fox in the 1st year of life
Tab. 1. Zarůstání lebečního švu BO-BS u lišky obecné v 1. roce života

suture BO-BS	open	occluding	closed	total
May–September	16	1	0	17
October	0	14	0	14
November	0	41	1	42
December	0	35	5	40
January	0	15	15	30
February	0	3	3	6
March	0	4	16	20
April	0	0	12	12

and metacone). It is no exception to find, in very old specimens (seven years and over), a completely worn molar with a smooth, non-differentiated surface on which only the distribution of the dark spots suggest the sites of earlier cusps. In this age even the dark blotches tend to fuse (Fig. 2F).

The study of tooth wear is among the historically earliest methods of estimating the age of mammals (Rybář 1970). In spite of this evident connection between age and tooth wear, however, it is difficult to compile a general scheme of tooth wear valid for any one species as the wear of individual teeth reflects the effects of several factors upon the general physical condition of an animal, from diet composition (particularly as regards the amount of minerals contained in the food) up to various diseases including caries (which, according to our observations, is far from being rare in a fox population) (van Bree et al. 1974). In evaluating the tooth wear it is also necessary to consider dental occlusion in any concrete animal: any deviations from the normal dental scheme, due either a loss of one or several teeth in the course of growing old or to inborn anomaly, may result in uneven loads on the chewing surface of molars and lead to the deviations mentioned above (Gingerich & Winkler 1979, Szuma 2002). Nevertheless, the degree of tooth wear is still among the most frequently used age criteria, as they permit rather easily to group the material under study into age groups (e.g. Stubbe 1989, Ansorge 1994). Other authors, however, rather accept tooth wear as an auxiliary criterion in combination with other methods of age determination (Pucek & Lowe 1975). Our own results are in full agreement with this opinion, since one tooth wear pattern may sometimes occur in up to three age categories (Fig. 2) so that in estimating the age of individual specimens by the sole wear of M^1, one must take into consideration a possible departure of up to two years (!) from the actual age.

Occlusion of cranial sutures

Our visual observations pertained to three cranial sutures: between *os basioccipitale* and *os basisphenoidale* (BO-BS), between *os praesphenoidale* and *os basisphenoidale* (PS-BS), and *sutura maxilloincisiva* between the intermaxilla and the maxilla (M-PM) (Figs. 3 and 4). Their advancing occlusion was estimated by using three degrees: *suture open* (occlusion not yet beginning), *suture occluding* (in various stages of the process), and *suture closed* (indiscernible).

Of the three cranial sutures under study, the BO-BS is the first to undergo occlusion. It remains open until 5–6 months of age (i.e. approximately until the first September of the cub's

Table 2. Occlusion of cranial suture PS-BS in Red fox during the first 3 years of life. Roman numerals indicate months of a calendar year; the respective years of life are given in brackets
Tab. 2. Zarůstání lebečního švu PS-BS u lišky obecné v prvních třech letech života. Římské číslice označují měsíc v kalendářním roce, v závorce je uveden příslušný rok života

suture PS-BS	open	occluding	closed	total
IV–VIII (1st year)	16	1	0	17
IX–XII (1st year)	0	14	0	14
I–IV (1st year)	0	41	1	42
V–VIII (2nd year)	0	35	5	40
IX–XIII (2nd year)	0	15	15	30
I–IV (2nd year)	0	3	3	6
V–VIII (3rd year)	0	4	16	20

life). It starts occluding from October onwards at 6–7 months of age, its beginning occlusion being observed as early as September. The process continues until next March. In April, at which time a fox will be about one year of age, the suture is already closed in all specimens and almost indiscernible on the skull base. Quite exceptionally, a closed BO-BS can be found as early as late November (i.e. at approximately 7.5 months of age). From December onwards the percentage of cases of closed BO-BS suture increases gradually until next April, at which age it is closed in 100% of specimens (Table 1, Fig. 5).

The PS-BS suture is the next to become occluded. The earliest signs of beginning occlusion were observed at the turn of November and December of the first year of life, and between January and April various stages of occlusion are observed in almost 80% of specimens.With

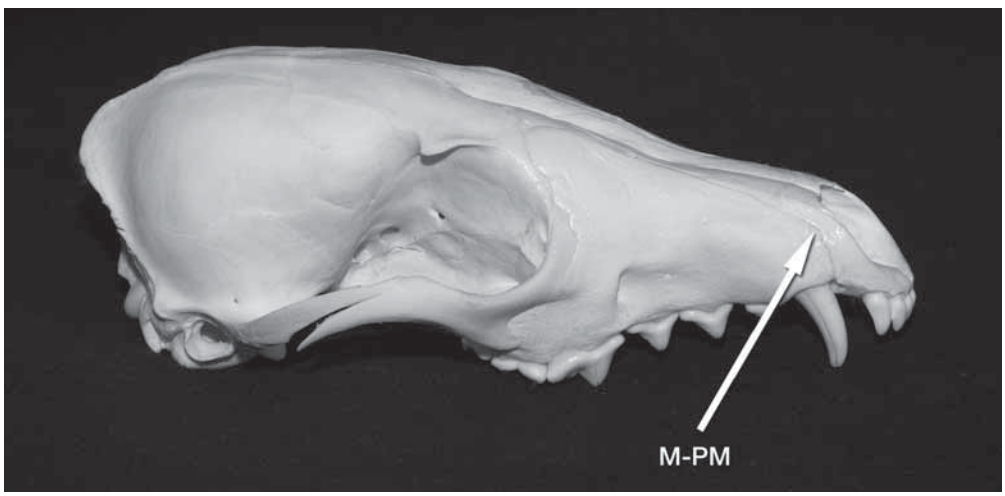

Fig. 4. Cranial sutures under study (2) M-PM (from Zapata et al. 1995) (photo by M. Hrdý).
Obr. 4. Sledované lebeční švy (2) M-PM (podle Zapaty et al. 1995) (foto M. Hrdý).

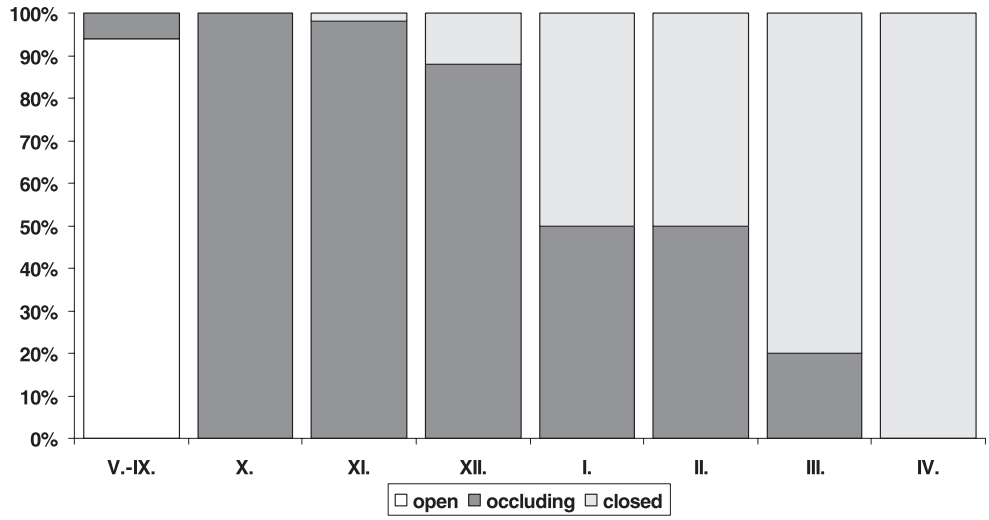

Fig. 5. Occlusion of cranial suture BO-BS in Red fox in the 1st year of life.
Obr. 5. Zarůstání lebečního švu BO-BS u lišky obecné v 1. roce života.

the advancing second year of life the percentage of occluding PS-BS gradually decreases and this suture is already completely closed in all specimens at the beginning of the third year of life (Table 2, Fig. 6).

The M-PM suture is the last to become closed. The earliest such cases occur at 21 months of age (i.e. at the end of the second year of life), whereupon the percentage of open sutures gradually decreases, the latest case being recorded as open at the end of the third year of life. In some specimens, however, partially occluded M-PM sutures can be observed until old age around 6–7 years; in others it is quite closed at the end of the fifth year of life (Table 3, Fig. 7).

The progressive occlusion of cranial sutures is connected with the degree of skull ossification, and it is evidently correlated with the age of the animal (Zapata et al. 1995). However, opinions on the reliability of this method differ (Churcher 1960, Harris 1978). Our own observations confirm that in free-living animals this criterion is only suitable for differentiating their age during the first two years of life, whereas it appears to be considerably unreliable and useless in the case of older age categories (among other things, due to considerably individual differences). For differentiating juveniles and subadults (usually yearlings) from adults, especially the occlusion of BO-BS appears to be useful. This is in accordance with the conclusions of Zapata et al. (1995) and Harris (1978), even though the latter found the occlusion of this suture to occur somewhat earlier in British foxes on the whole. The time sequence of the occlusion of BO-BS in our material basically agrees with the observations of the two above authors. In spite of the deviations mentioned, the suture appears to be suitable (particularly in combination with the degree of ossification of the remaining sutures as well as with tooth wear) for differentiating foxes 1.0–1.5 years of age from those 2.0–2.5 years of age (naturally using the theoretical birth and death dates).

Table 3. Occlusion of cranial suture M-PM in Red fox over the whole life
Tab. 3. Zarůstání lebečního švu M-PM u lišky obecné v průběhu celého života

suture P-PM	open	occluding	closed	total
1 year	181	0	0	181
2 years	94	4	0	98
3 years	14	11	0	25
4 years	0	16	0	16
5 years	0	10	1	11
6 years	0	6	2	8
7 years and more	0	3	2	5

The last of the sutures under study, M-PM, shows the greatest irregularities when compared with the results presented by other authors. While HARRIS (1978) reports this suture as occluding between the beginning of the third and the end of the sixth year of life, ZAPATA et al. (1995) tend to report this interval as between the beginning of the 2nd and the end of the 3rd year of life. According to CHURCHER (1960), in North American foxes this suture occludes between the 4th and 6th year of life. The above differences are fundamental enough not to recommend the use of this criterion in determining the age of the red fox.

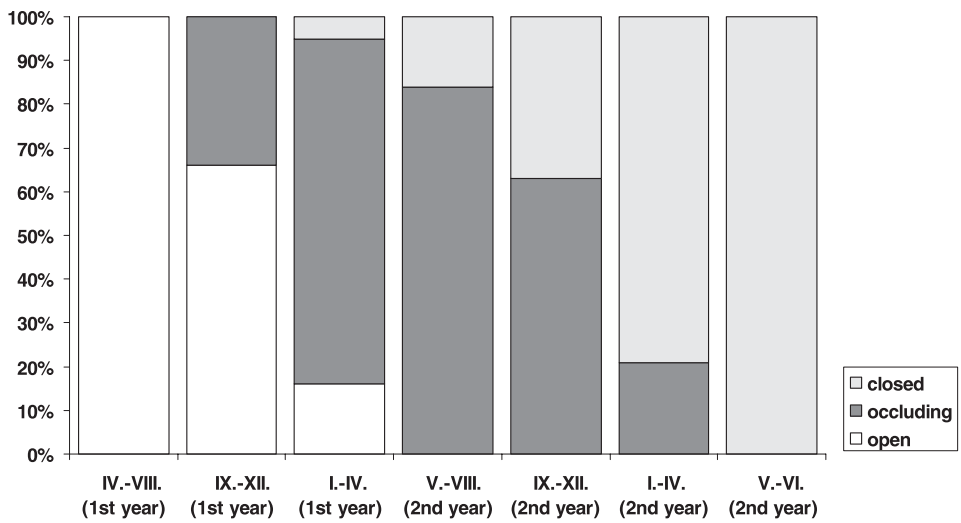

Fig. 6. Occlusion of cranial suture PS-BS in Red fox during the first 3 years of life. (Roman numerals indicate months of a calendar year; the respective years of life are given in brackets.)
Obr. 6. Zarůstání lebečního švu PS-BS u lišky obecné v prvních třech letech života. (Římské číslice označují měsíc v kalendářním roce, v závorce je uveden příslušný rok života.)

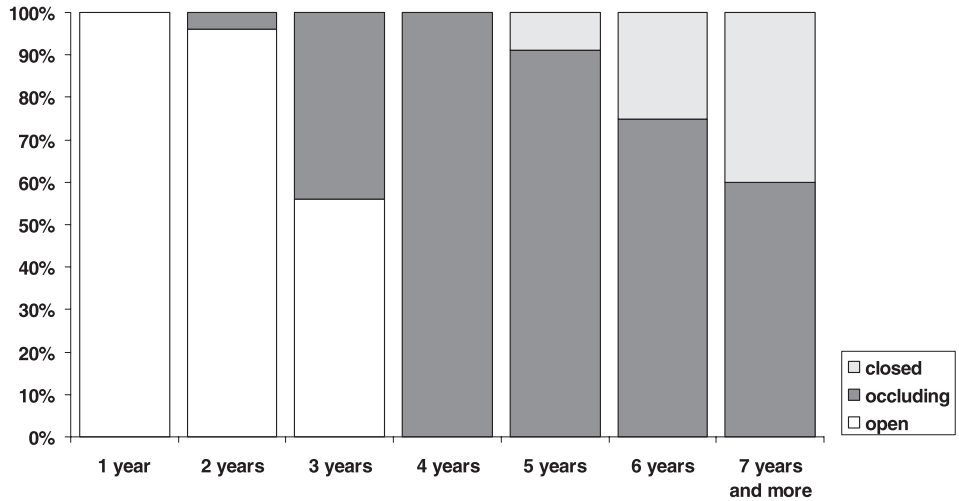

Fig. 7. Occlusion of cranial suture M-PM in Red fox in the course of life.
Obr. 7. Zarůstání lebečního švu M-PM u lišky obecné v průběhu života.

Occlusion of dental pulp

The occlusion of dental pulp cavity is directly correlated with the appositional growth of secondary dentine filling up the cavity. This that the resulting fissure values process advances throughout individual life (Harris 1978), yet the period of progressive occlusion of the dental pulp is considered to take place during the first two years of life (Dolgov & Rossolimo 1966, Cavallini & Santini 1995a). This is so in all teeth of the dentition, but the canine is the most suitable for following up this process (due to its simpler form and larger dimensions). The current method is to take measurements of the width of dental pulp and the outer dimensions of the tooth from an X-ray photo (Cavallini & Santini 1995a, Zapata et al. 1995) or from a transverse section through the tooth (Harris 1978, Goszczynski 1989).

The drying up of prepared skulls is accompanied by a tension in the teeth, a phenomenon that has not been studied so far. In young specimens, due to their considerably wide pulp cavity, this tension results in various degrees of longitudinal fissures developing in the crowns of all teeth (Fig. 8). In this point, all four normally developed canines on each skull (the continuity of dental pulp occlusion being disturbed in damaged teeth) were assessed visually and the size of crown fissure was classified using a four-degree scale (Fig. 8): degree 3 – *fissure wide open*, visible at first sight, dividing the crown into two separate parts; degree 2 – *fissure distinct*, passing throughout the undivided crown; degree 1 – *fissure almost indiscernible*, often only a deep furrow present on buccal side of crown; degree 0 – *no fissure present*. The values of the above degrees were summarised for the four canines separately on each skull (the resulting values ranging between 0 and 12)

It is evident from the data in Table 4 and Fig. 9 that the resulting fissure values 9–12 occur only in teeth of specimens less than 1 year of age (64%). Values 5–8 are characteristic of specimens at the end of the 1st year of life (almost one third of this age class) and, at the same

Table 4. Frequency of occurrence of different fissure sizes of canine crowns in different age groups (sums of fissure size degrees in all four canines)
Tab. 4. Četnosti výskytu různých velikostí fisur korunek špičáků u jednotlivých ročních věkových tříd (součet stupňů velikost fisury všech čtyř špičáků)

fissure size	sum 9–12	sum 5–8	sum 1–4	sum 0
1 year	116	55	9	1
2 years	0	19	71	8
3 years	0	0	9	16
4 years	0	0	0	16
5 years	0	0	1	10
6 years	0	0	0	8
7 years	0	0	0	5

time, at the beginning of the 2nd year of life (19% of such cases). Values 1–4 are attained by a smaller fraction (5%) of yearling specimens, most of specimens at 2 years of age (73% of this age group), and over one third of specimens in the 3rd year of life. The zero value, although it

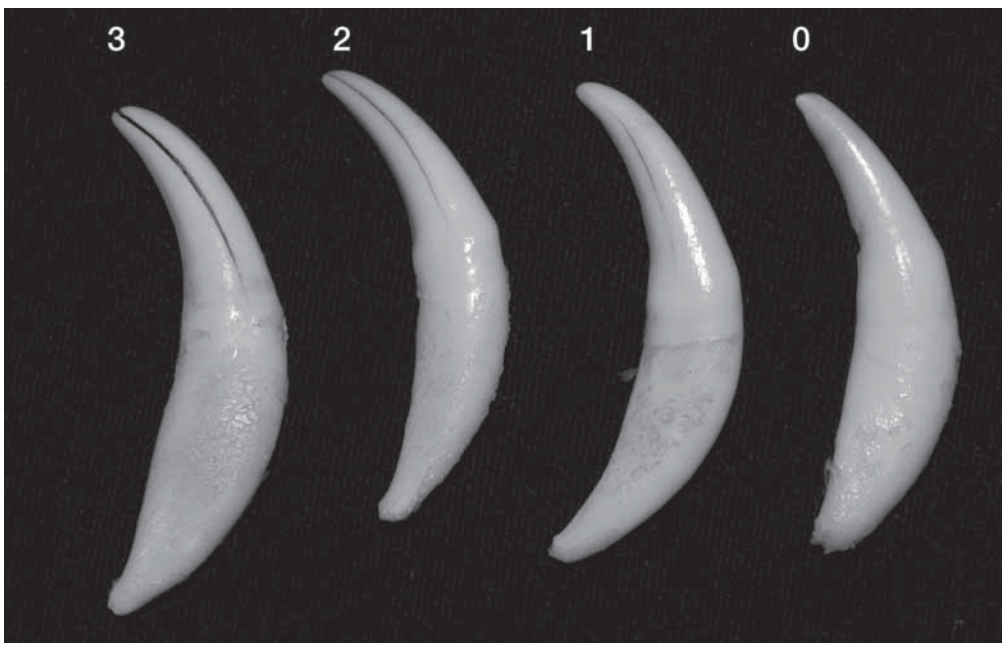

Fig. 8. Extent of longitudinal fissure on canine crown and its interpretation (here on the example of upper left canine; for the sake of plasticity, the fissure was „soiled“ in nos. 2 and 1) (photo by M. Hrdý).
Obr. 8. Rozsah podélné fisury na korunce špičáku a její ohodnocení (zde na příkladu levého horního špičáku; pro lepší názornost rýha „zašpiněna“ u č. 2 a 1) (foto M. Hrdý).

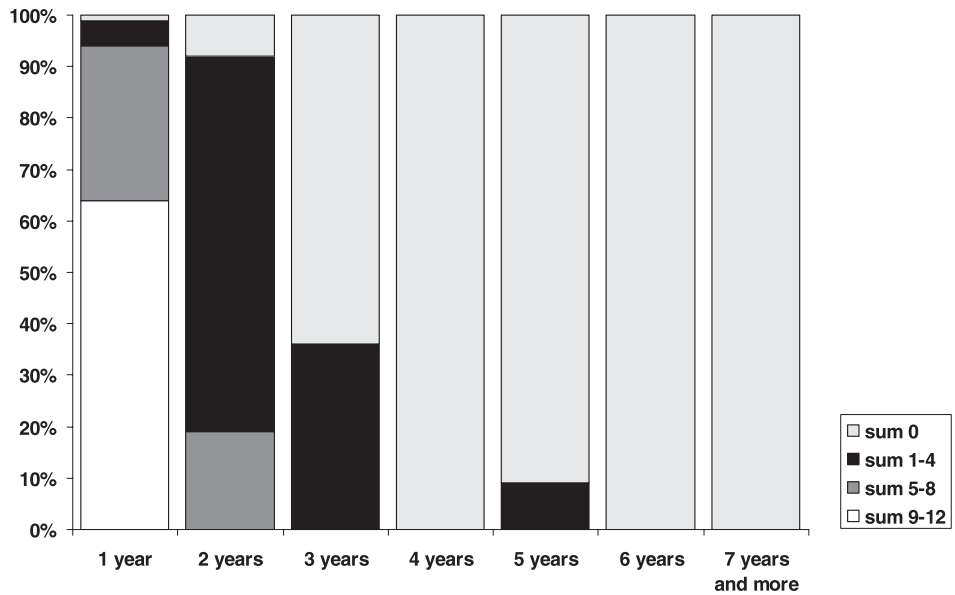

Fig. 9. Frequency of occurrence of different fissure sizes on canine crowns in different age groups.
Obr. 9. Četnosti výskytu různých velikostí fisur korunek špičáků u jednotlivých ročních věkových tříd.

may exceptionally occur in specimens one year of age (less than 1%) and occasionally in those 2 years of age (8%), is characteristic for specimens three years of age and over. The absence or exceptional presence of a small canine crown fissure (the resulting values 0 or 1–4) in young specimens less than one year of age (6%) can occur in very small (often female) individuals with small-sized teeth.

Our evaluation of the sizes of canine crown fissure found on prepared skulls of our red fox populations is in good fit with the conclusions of authors who studied the occlusion of dental pulp in relation to age, using classical procedures (Harris 1978, Cavallini & Santini 1995a). According to their observations, the dental pulp is rather quickly occluded during the 1st and early 2nd year of life, at which time the first increment of dental cement develops. At the end of the 2nd year of life the dental pulp becomes just a narrow fissure which thereafter diminishes only inappreciably despite the fact that the secondary dentine increments continue to develop each subsequent year. Thus, the study of the fissure size permits, in a very simple way, to separate yearling and two-year-old specimens from older ones.

Increment layers of secondary dental cement

Counting the increment layers of secondary dental cement is considered to be the relatively most exact method of determining the age of red fox. In sections through the tooth roots, they appear as characteristic annual rings consisting in paler (summer) opaque and darker (winter) transparent areas (e.g. Klejnenberg & Klevezal 1966, Grue & Jensen 1973, Harris 1978, Nelson &

Fig. 10. Example of a ground preparation of a canine made with sand paper. A, intact upper canine; B, sanded upper canine of a young (9-month-old) specimen; C, sanded upper canine of a four-year-old specimen; D, a more slanting sanded area on a lower canine of a six-year-old specimen, with minimum damage done to the crown (photo by M. Hrdý).
Obr. 10. Ukázka výbrusu špičáku zhotoveného ručním zbroušením brusným papírem. A nezbroušený horní špičák, B zbroušený horní špičák mladého, 9-ti měsíčního jedince, C zbroušený horní špičák čtyřletého jedince, D šikměji zbroušený dolní špičák šestiletého jedince jen s minimálním poškozením korunky zubu (foto M. Hrdý).

Chapman 1982, Cavallini & Santini 1995a, Zapata et al. 1995). Longitudinal sagittal sections are more satisfactory, as in the technically simpler transverse sections the interpretation of the number of increment zones may be problematical since the cement layers are not uniformly spaced on the outside of the root and, hence, it is significant to select a suitable level of the section. While the reliability of this latter method is up to 90% (Grue & Jenssen 1973), its considerable drawback is in being considerably time-consuming. Instead of the time-consuming method of histological sections, we used a much simpler method of counting the increment layers of secondary dental cement, based on longitudinal sanding preparations of dental roots (Fig. 10) (Roulichová & Anděra 2007). The age of specimens older than one year of age is estimated by simply counting the dark lines and adding the number of months between estimated birth date (in central Europe this is on April 1st on average) and the known date of death. The dark lines are most satisfactorily discernible at the sides of the root close to its apex (Fig. 11). In all, we produced longitudinal sanding preparations of one or two canines in 116 specimens of red fox skulls, and determined their age as ranging from one to almost eight years, those three years of age predominating (65.5%).

Determining the age of red fox: instructions for use

The results obtained in this study were used to compile a tentative tool to be used in determining the age of red fox up to 2 years of age, using external characters on their skull and dentition and subsequently by means of increment layers of secondary dental cement on tooth roots. However, the above characters are of approximate value only as in individual cases they may be affected by the physical condition of the animal, diet composition, diseases, etc.

Age category up to 6 months of life
Ongoing development and allometric growth of skull. All three sutures under study are open, milk teeth are gradually replaced by permanent dentition, the first upper molar of fully developed permanent dentition shows no signs of wear, in a prepared skull all four canines (sometimes even other teeth) show a longitudinal fissure dividing the crown into two separated halves (degree 3).

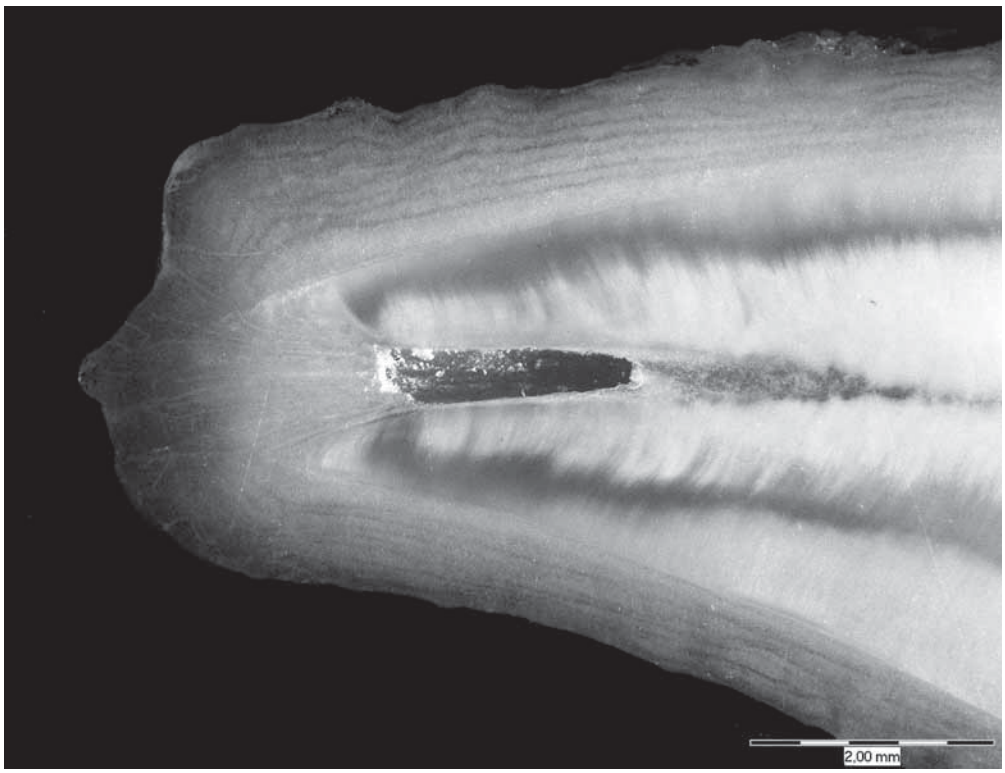

Fig. 11. Sanded root of upper canine of a female red fox almost 8 years of age (seven fully developed lines, eighth line discernible on outer margin of root).
Obr. 11. Výbrus kořene horního špičáku samice lišky ve věku téměř 8 let (sedm plně zformovaných linií a osmá linie viditelná na vnějším okraji zubu)

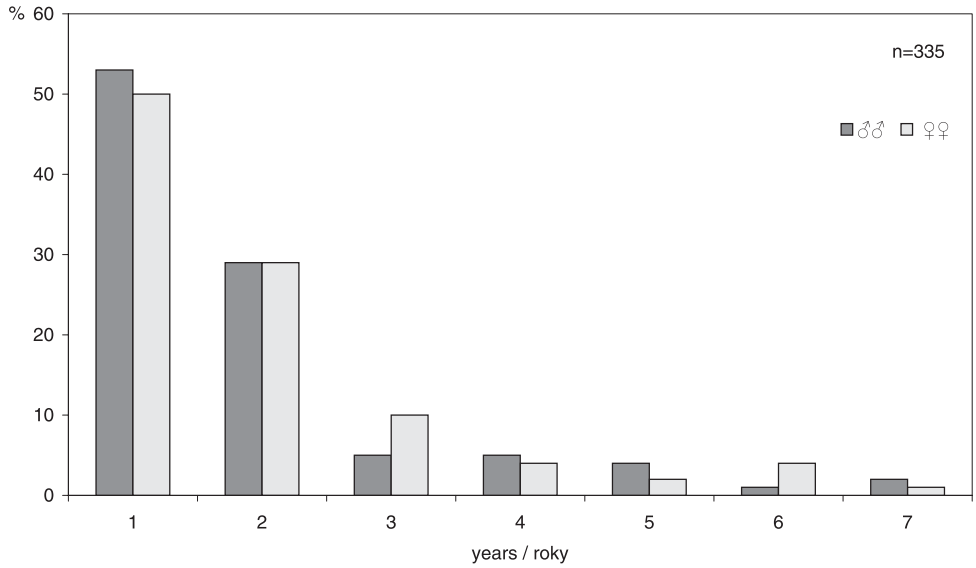

Fig.12. Age structure of a red fox population sample from the Czech Republic.
Obr. 12. Věková struktura vzorku lišky obecné z ČR.

Age category 7–12 months of life
The skull attains its full size, suture BO-BS occluding or fully occluded, suture PS-BS still open (the same as suture M-PM) or occluding, suture M-PM remaining open. Permanent dentition complete, M^1 showing no or only feeble wear of one cusp (metaconule)or exceptionally two cusps (metaconule and paraconule or metaconule and protoconule) canine crowns with persisting extensive fissure either distinctly separating the crown halves (degree 3) or only passing all along the crown (degree 2).

Age category 13–18 months of life
Skull fully developed, with suture BO-BS completely occluded, suture PS-BS occluding are likewise closed, suture M-PM still open; M^1 shows various degrees of slight wear (most frequently one or two different cusps, sometimes even three cusps at the same time), quite rarely the M^1 is still intact and the fissure passes the whole canine crown (degree 2) or, more frequently, in form of only a shallow longitudinal furrow is present on the buccal side of the tooth (degree 1), or, as an exception, no fissure is discernible.

Age category 19–24 months of life
Skull fully developed, suture BO-BS fully occluded, suture PS-BS occluded or occluding, suture M-PM still open or quite exceptionally beginning occlusion is observed; M^1 showing distinct wear of two or three cusps (less frequently of only one or, on the contrary, up to four cusps), the longitudinal fissure of canine crowns inconspicuous, poorly discernible (degree 1) or absent (degree 0).

Age category two years and over
Skull fully developed, sutures BO-BS and PS-BS completely occluded, suture M-PM still open or showing various stages of occlusion; M^1 with at least 3 and often more cusps (including cingulum) worn, canine crown showing no fissure or quite exceptionally a feebly discernible furrow on buccal side (degree 0). The age can be determined more precisely by counting increment layers of secondary dental cement on tooth roots. Knowing the date of death (kill) and approximate date of birth (which can be inferred theoretically from the natural conditions of the respective region and habitat), the actual individual age can be fairly precisely calculated to the nearest month.

Age structure

The above data were used to evaluate the age structure of a red fox population sample obtained from various regions of the Czech Republic, which, to a certain extent, can reflect the actual status of free-living populations. The evaluation involved a total of 335 specimens of known sex. The results show that roughly one half of the sample are young individuals up to one year of age (♂♂ 53%, ♀♀ 50), about one third are two-year-old ones (♂♂ and ♀♀ 29% each) and the rest (around 20%) are individuals older than two years (Fig. 12). The mean age of both sexes pooled is 17.9 months, the differences between sexes apper to be insignificant (♂♂ 18.1 months, ♀♀ 17.7 months). In our study, the oldest male attained the age of 83 months (i.e. almost seven years), the age of the oldest female was estimated at 95 months (i.e. eight years short three months).

Wandeler & Lüps (1993) present a general statement that red fox population samples contain 50–78% individuals less than one year of age and that the longest attained age is approximately 10 years. Our own results quite agree with their statement even though other authors recorded a much marked share of the youngest age categories. For instance, Ansorge (1994) found, in a sample from Germany, almost 80% individuals less than 1 year old and only 6% those older than two years, and Jensen & Nielsen (1968) report a similar age structure from Denmark (74% individuals younger than one year and 15% older than two years). Beyond doubt, the different results obtained from different population samples do reflect, besides population parameters, even different methods employed in obtaining material (e.g. ways and/or time of hunting).

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SOUHRN

Práce shrnuje výsledky srovnání několika nemetrických metod určování věku u lišky obecné s pomocí lebečního materiálu. Sledován byl stupeň obrusu zubů (M^1) a zarůstání vybraných lebečních švů (*os basioccipitale-os basisphenoidale*, *os presphenoidale-os basisphenoidale* a *sutura maxilloincisiva*), dále velikost podélné fisury na korunkách špičáků a počet přírůstkových vrstev sekundárního zubního cementu. Obrus M^1 vykazuje poměrně velké individuální rozdíly s odchylkou až dva roky od skutečného věku jedince. Z lebečních švů se k odlišení juvenilních a subadultních (obecně tohoročních) zvířat od adultních zvířat hodí časová posloupnost uzavírání švu mezi *os basioccipitale-os basisphenoidale*, inter-

val zarůstání švu mezi *os presphenoidale-os basisphenoidale* pak umožňuje vcelku spolehlivé odlišení lišek starých 1–1,5 roku od lišek starých 2–2,5 roku (pochopitelně s využitím teoretického data narození a data úhynu). Postup uzavírání zubní pulpy lze sledovat podle přítomnosti a velikosti podélné fisury na špičácích, která vzniká jako artefakt v důsledku sesychání vypreparovaných lebek; pomocí tohoto znaku lze určit věk lišky do dvou až tří let. Byla sestavena orientační pomůcka k odhadu přibližného věku lišky obecné do stáří dvou let s využitím vnějších znaků na lebce a dentici. U starších jedinců lze odhad věku získat sčítání přírůstkových vrstev zubního na podélných výbrusech kořenů zubů (nejlépe špičáků). Ve zpracovávaném vzorku lišky obecné z různých míst České republiky představují zhruba polovinu vzorku mladí jedinci do věku jednoho roku (♂♂ 53 %, ♀♀ 50 %), lišky ve 2. roce života tvoří asi třetinu (♂♂ i ♀♀ 29 %) a jen zbylá část okolo 20% je zastoupena jedinci staršími dvou let (obr. 12). Průměrný věk zpracovávaného vzorku lišky obecné z území ČR je 17,9 měsíce (♂♂ 18,1 měsíce, ♀♀ 17,7 měsíce), nejstarší jedinec (♀) dosáhl odhadovaného věku 95 měsíců.

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