BEAUFORTIA

SERIES OF MISCELLANEOUS PUBLICATIONS

ZOOLOGICAL MUSEUM OF THE UNIVERSITY OF AMSTERDAM

No. 226 Volume 17 February 20, 1970

Sex and age composition of a Stoat population (*Mustela erminea* Linnaeus, 1758) from a coastal dune region of the Netherlands

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Abstract

The age composition of a sample of a Stoat population from the Netherlands was studied. Various relative age criteria were tested on their validity in separating age groups. The study of the layered cemental deposits contributed the most important part to the final conclusions. By using also the data on the sexual cycle of the Stoat, a theoretically expected age pyramid was calculated, which was compared with the actually found age composition.

Introduction

The only way to acquire accurate age data from wild animals is by marking and recapturing. Various authors have taken advantage of this method by comparing the absolute age data thus acquired with relative age indicators, e.g. developmental processes of various parts of the body. Not all animals, however, submit without difficulty to marking. Attempts have been made to mark young Stoats, but invariably these were found dead after a short time, probably by thyriotoxicosis. Consequently, the age data used in this study lack absolute proof.

Nevertheless much can be learned by comparison of different relative age indicators, although the ultimate results can only be presumed to be true. Relative age indicators available were: body dimensions, skull dimensions, formation of the sagittal crest of the skull, tooth wear, baculum dimensions, formation of the lateral suprasesamoidal tubercle of the femur, distinctness of nipples, closure of skull sutures and epiphyseal junction in long bones.

A more absolute age indicator was found in the formation of annual layers in the tooth cementum, made visible by histological preparation. Although various authors have proved that there is a direct correlation between the age in years of e.g. Foxes (Jensen & Nielsen, 1968), Shrews (Kleinenberg &

Received: October 7, 1969.

Klevezal, 1966), Groundsquirrels (Adams & Watkins, 1967), and the numbe; of cementum layers in their teeth, no such proof exists in this case, for none of the animals used in this study have been marked. Nevertheless, this method was considered useful for comparison with other age indicators.

By compiling the data obtained from the study of the age composition of a population sample and the sexual cycle of the animal, one is able to describe, to a certain extent, the present state of the population.

Material and Methods

The material used for this study consisted of 150 animals from a coastal dune region in the Netherlands, viz. in the province of Noord-Holland, between IJmuiden and Egmond. The animals were collected on the occasion of a joint research project together with the National Institute for Nature Management (formerly ITBON) on *Mustela erminea* during the years 1965, 1966 and 1967 (Heitkamp & van der Schoot, 1966; see also van Soest & van Bree, 1969). The area was divided into five parts; in three of these every Stoat encountered was shot in order to study the difference between the parts in predation on Pheasants. Pelts and skeletons were incorporated in the collections of the Zoological Museum of Amsterdam.

The following measurements were taken.

Body measurements: total length, tail length, length of the hind foot, ear length and body weight.

Skull measurements: condylobasal length, basal length, zygomatic breadth, mastoid breadth, rostral breadth, breadth of the postorbital constriction, length of the toothrow, heigth of the skull over bullae.

Other measurements: length of the testis, weight of the testis (34 animals), weight of the ovaries (43 animals), baculum length, baculum weight, height of the proximal protuberance of the baculum (21 animals).

The development of the sagittal crest of the skull was evaluated by use of arbitrary units 1, 2, 3, 4, and 5 (1 stands for: no sagittal crest, 5 for: maximally developed crest). In the same way the abrasion of the teeth (1, 2, 3, 4, and 5), the closure of skull sutures (1, 2, and 3) and the development of the lateral suprasesamoidal tubercle of the femur (1, 2, and 3) were judged.

The cemental layers of 37 canines (20 male, 17 female) were made visible by histological preparation, as described by Jensen & Nielsen, 1968. The teeth were decalcified in 5% HNO_3 for about 17 hours, then washed in running tapwater for 24 hours (acid removal), after which the teeth were cut longitudinally into sections of 30 microns by way of a freezing microtome. Mayer's haemalun und Ehrlich's haemalun were both used as colouring fluid.

Microscopic preparations of 33 testes and 2 ovaries were made, all coloured with haemalun-eosine, for the study of the sexual cycle of the Stoat.

For the statistical treatment of the obtained data the following formulae were used (after Moroney, 1951, and Wijvekate, 1961): Standard deviation, t of Student, correlation coefficient, regression and standard deviation of regression.

ACKNOWLEDGEMENTS

The authors are grateful to Drs. W. J. Doude van Troostwijk and other staff members of the National Institute for Nature Management (formerly ITBON) for their cooperation in this study, to Dr. A. van der Stelt, Dr. W. L. van Utrecht and Drs. P. C. Diegenbach of the Zoological Laboratory of the University of Amsterdam for their cooperation and advice, and finally to the management and the gamewardens of the Provinciaal Waterleidingbedrijf van Noord-Holland (P.W.N.) for their help. The authors also want to thank most sincerely Dr. Colin P. Groves (Cambridge) for reading and checking the manuscript.

RESULTS

Among the 150 animals, 63 were female and 87 male, a ratio of about 2 : 3. This ratio is commonly encountered in sampling carnivorous mammals.

1. *Age determination based on relative indicators:*

1.1. Males:

Popov (1943) distinguished juvenile and adult Stoats by the weight and the morphology of the baculum. Juvenile animals were characterized by a baculum weight less than 32 mg and absence of a proximal baculum protuberance. Adult animals were characterized by a baculum weight exceeding 32 mg and the presence of a baculum protuberance. In this case "adult" means sexually adult, for the body dimensions of the Stoat may be maximal in the fourth month from birth. Full grown animals which do not possess a proximal baculum protuberance (i.e., which have not yet been sexually active) will be indicated as subadult in this paper. Not fully grown animals will be indicated as juvenile. The distinction between bodily adult and not fully grown animals was made by using the closure of skull sutures as an indicator. All animals with non-closed or nearly closed sutures were considered to be juvenile. The composition of the male part of the material was in this way found to be: 10 juveniles, 56 subadults and 21 adults. Other potential relative age indicators were checked on this subdivision.

1.1.1. Body measurements: By comparison of juvenile, subadult and adult animals it appeared that at the age of about four months all Stoats are fully grown. Thus no relationship could be found between age and body dimensions in later stages of life (see table I).

TABLE I. Statistical data of body measurements of male Stoats

a. Total length (mm)

	juvenile		subadult		adult
m (mean)	275.40		361.75		367.91
s (range)	132—378		326—398		332—391
s.d. (standard deviation)	62.80		15.13		18.88
t (value of t of Student)		8.61		1.47	
p (probability of differences being insignificant)		< 0.1%		25—10%	
n (number of animals used)	10		54		21

b. $\sqrt[3]{\text{Weight}}$ (g)

	juvenile		subadult		adult
m	5.06		6.47		6.57
s	19—216		196—365		242—368
s.d.	0.89		0.32		0.33
t		6.41		0.40	
p		< 0.1%		> 50%	
n	10		54		21

c. Tail length (mm)

	juvenile		subadult		adult
m	71.20		101.57		105.00
s	27—99		84—119		92—123
s.d.	20.62		7.32		7.77
t		19.50		1.77	
p		< 0.1%		10—5%	
n	10		54		21

d. Length of hindfoot (mm)

	juvenile		subadult		adult
m	36.60		45.90		46.20
s	16—43		40—51		43—50
s.d.	7.39		2.72		2.17
t		5.20		0.45	
p		< 0.1%		> 50%	
n	10		55		21

e. Ear length (mm)

	juvenile		subadult		adult
m	19.00		22.60		22.50
s	7.5—24		19—26		17.5—25
s.d.	4.07		1.97		1.90
t		4.29		—	
p		< 0.1%		—	
n	10		55		21

1.1.2. Skull measurements: The same tendency found in the body measurements appeared to exist in the skull dimensions. After about four months the skull showed no perceptible increase in any dimension (see table II).

TABLE II. Statistical data of skull measurements of male Stoats.

a. Condylobasal length (mm)

	juvenile		subadult		adult
m	40.40		48.59		48.73
s	26.7—46.9		45.7—51.0		46.4—54.0
s.d.	6.58		1.26		1.72
t		5.77		0.17	
p		< 0.1%		> 50%	
n	6		41		18

b. Zygomatic breadth (mm) expressed as index zyg.br./cbl. × 1,000

	juvenile		subadult		adult
m	591.30		570.90		571.10
s	602—580		600—493		616—485
s.d.	10.97		19.23		26.50
t		1.77		0.03	
p		10—5%		> 50%	
n	3		36		16

c. Mastoid breadth (mm) expressed as index mast.br./cbl. × 1,000

	juvenile		subadult		adult
m	539.20		476.20		478.60
s	588—484		509—432		507—431
s.d.	33.33		14.66		19.04
t		7.46		0.56	
p		< 0.1%		> 50%	
n	5		44		17

d. Height of the skull (mm) expressed as index skull height/cbl. × 1,000

	juvenile		subadult		adult
m	447.40		391.50		383.10
s	509—412		417—361		403—343
s.d.	32.82		9.16		17.01
t		8.94		2.33	
p		< 0.1%		5—2%	
n	8		40		16

e. Postorbital constriction (mm)

	juvenile		subadult		adult
m	12.80		12.07		11.53
s	8.9—14.3		10.5—13.0		10.6—13.4
s.d.	1.74		0.61		2.03
t		2.15		1.59	
p		5—2%		25—10%	
n	8		47		17

1.1.3.Epiphyseal junction in long bones (Stewart & Trotter, 1954; Krogman, 1962): The process of junction of epiphyses in the femur appeared to run parallel to the closure of skull sutures. In the fifth month from birth all animals show joined epiphyses. The stages of non-junction and near-junction were considered to be juvenile characteristics.

1.1.4. Measurements of the baculum: Table III, figs. 1 and 2.

1.1.4.1. Baculum weight: A clear distinction appeared to exist between the adult and young animals with no overlap of importance; adults having baculum weights exceeding 30—32 mg. By using thc date of death of the animals the following facts can be concluded (fig. 1): juvenile animals possess a hardly developed baculum (in one case it could not even be preserved), not weighing more than 15 mg at the end of the juvenile stage. Subadults possess a baculum weight from 15 up to 32 mg, occurring in the period from August till February. In February adulthood is reached with the appearance of the baculum protuberance and a baculum weight of 30—32 mg. Fig. 1 demonstrates that from this stage onwards, the baculum continues to increase in weight up to about 60 mg.

This implies further growth possibly related to age. To allow a possible subdivision of adult males into age groups, more evidence of the validity of the baculum weight as an indicator of adult age is needed. It will be supported later.

1.1.4.2. Baculum length: From table III can be seen that there is a statistical significant difference between juvenile, subadult and adult males in respect of the length of the baculum. There is, however, also a considerable overlap between subadults and adults and no major increase in length after reaching adulthood.

Baculum length and baculum weight were considered together by way of using the index length/weight (van Bree, Jensen & Kleijn, 1966), but no new aspects appeared.

TABLE III. Baculum data of juvenile, subadult and adult Stoats.

a. Baculum weight (mg):

	juvenile		subadult		adult
m	7.40		21.99		43.02
s	1.3—18.5		14.5—32.3		31.0—60.8
s.d.	6.44		4.81		9.25
t		7.44		4.00	
p		< 0.1%		< 0.1%	
n	8		54		21

b. Baculum length (mm):

	juvenile		subadult		adult
m	16.20		23.06		25.13
s	8.1—24.5		19.4—25.5		23.0—27.3
s.d.	5,39		1,17		1,15
t		8.27		2.16	
p		< 0.1%		5—2%	
n	8		54		21

1.1.4.3. Height of the proximal end of the baculum: During the measurements of the bacula it was observed that the size of the baculum protuberance seemed to increase with higher baculum weights. This was investigated by measuring the height of the protuberance and plotting this against the baculum weight (fig. 2). To some extent this tendency appeared to exist, althought at the highest weight values no further increase in height of the protuberance was found. It was furthermore investigated, whether the height of the protuberance was not solely dependent on the general increase in length of the baculum as a whole. The correlation coefficient of protuberance height and baculum length proved to be 0.38, which is, with 20 degrees of freedom, clearly not significant on the 5% level of probability. The height of the baculum protuberance is apparently independant of baculum length.

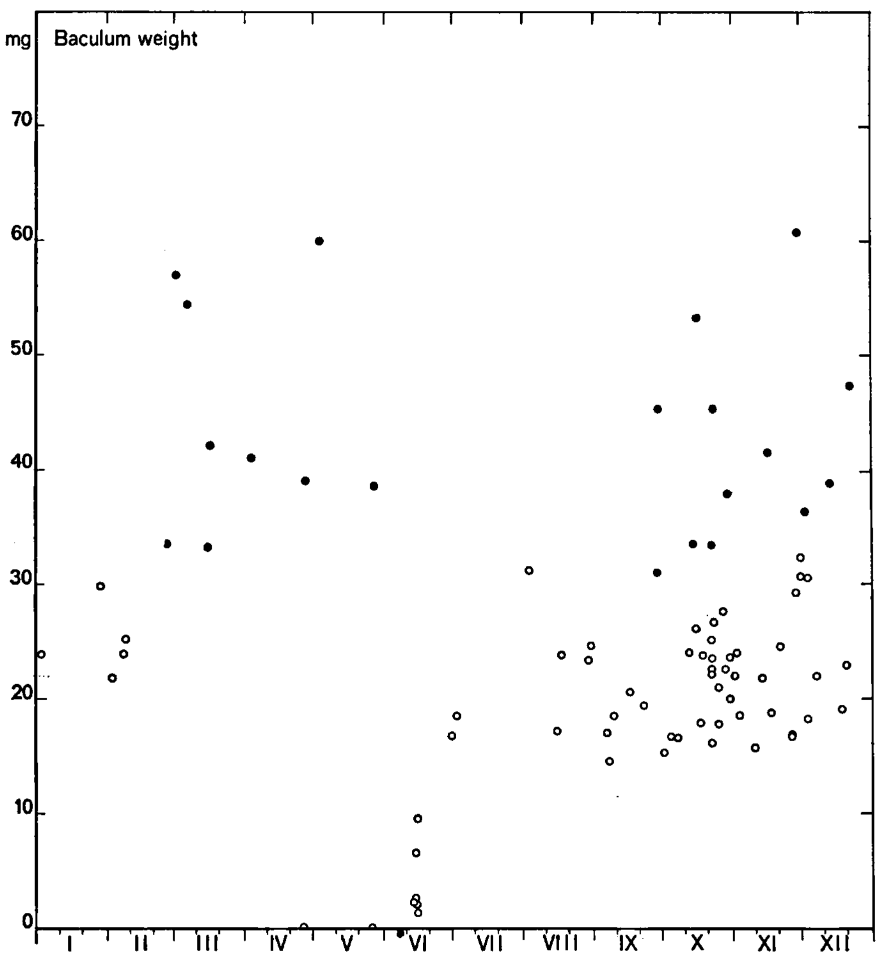

FIG. 1. Baculum weights of 87 ♂ Stoats, arranged according to date of death. Open circles young animals, black circles adults.

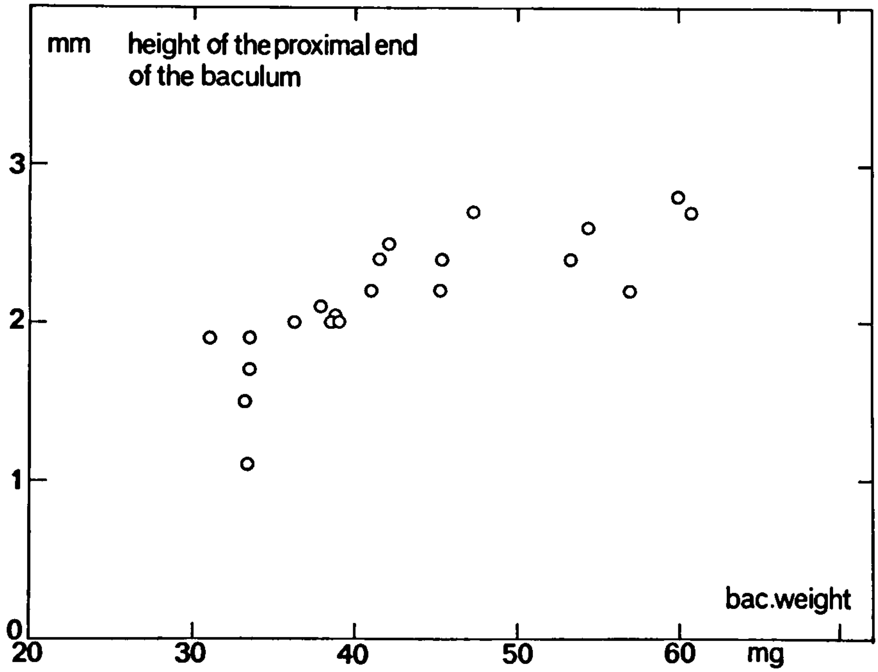

FIG. 2. Relation between the baculum weight and the height of the proximal baculum protuberance of 21 adult ♂ Stoats.

The results acquired in this way allow a certain subdivision of baculum weight groups, but first the relation with age has to be established.

1.1.5. Development of the sagittal crest: Table IV, fig. 3. Reichstein (1957) considered the characteristics of the sagittal crest of the skull to be sex-linked. Females were supposed to have no crest at all, while males were characterized by a strongly developed crest. Females with a crest and males with no crest were considered to be respectively mannish and effeminate. However, later investigations by Reinwaldt (1959), Bährens (1959) and Heran (1966) with different Mustelidae showed, that the development of the sagittal crest depends on the development of the skull and has only indirectly to do with sex. For both male and female skulls show different phases in crest development. As males, however, generally possess bigger skulls than females, it is clear, that mostly males show stronger developed crests.

Evaluation of the development of the sagittal crest of individual skulls was established in an arbitrary way. The maximally developed crest extends only a few millimeters above the braincase, so no measurements could be taken. In stead of this the skull was given a rank number: no crest (1), slightly developed (2), moderately developed (3), strongly developed (4) and maximally developed (5). In this way a positive correlation was found with the condylobasal length (fig. 3), the correlation coefficient being 0.44 (n = 70).

This correlation suggested a possible indication of age by the development

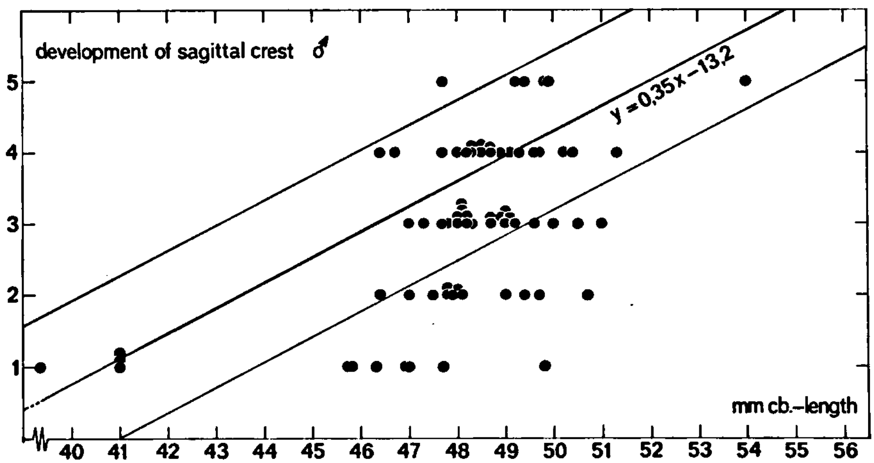

FIG. 3. Relation between the condylobasal length and the development of the sagittal crest of 70 ♂ Stoats.

of the sagittal crest. From table IV it can be seen that there do indeed exist significant differences in development between juveniles, subadults and adults, although maximally developed crests do occur with subadults.

1.1.6. Tooth wear: This was judged by the same standards as the development of the sagittal crest. Attention was paid to the canines in particular. There appeared to be no correlation between tooth abrasion and ageing. Apparently the wear of the teeth, with Stoats, is dependent on other factors.

1.1.7. Development of the lateral suprasesamoidal tubercle of the femur

TABLE IV. Development of the sagittal crest of the skull of juvenile, subadult and adult ♂ Stoats (expressed in arbitrary units 1, 2, 3, 4, 5).

	juvenile		subadult		adult
m	1.40		2.80		4.00
s	1—3		1—5		3—5
s.d.	0.80		1.08		0.79
t		11.67		4.44	
p		$< 0.1\%$		$< 0.1\%$	
n	10		51		20

(figs. 4 and 5): Leichleitner (1954) and Greer (1957) were able to distinguish known age juvenile ranch Minks (*Mustela vison*) from adults by the absence or presence of a little tubercle for muscle attachment on the distal end of the femur. This method was found to be reliable to a probability of 89%.

The phenomenon was checked with Stoats and a reasonable accordance was found with the baculum method. Three stages of development of the tubercle were distinguished (fig. 4): stage *a* with a fully developed tubercle, stage *b* with a visible but indistinct tubercle, and stage *c* with no tubercle

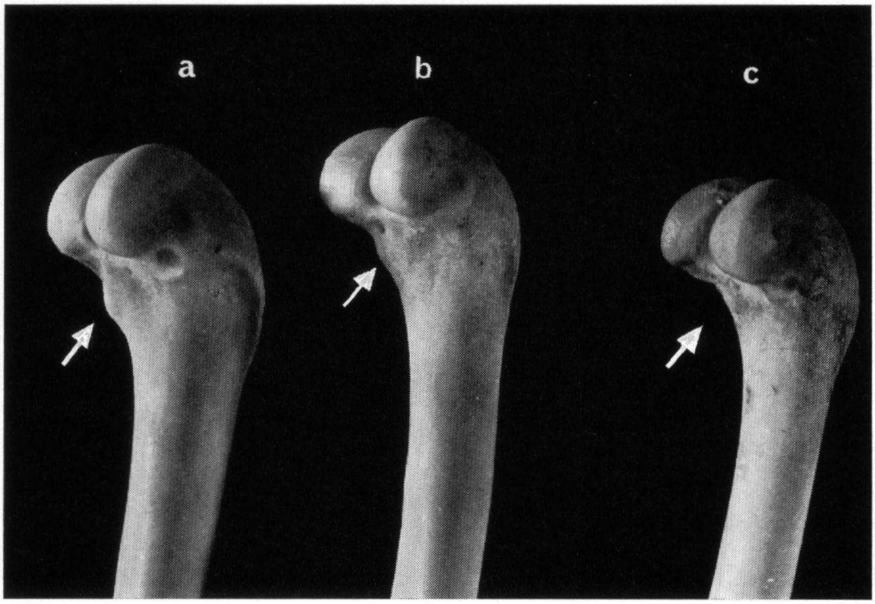

FIG. 4. Development of the lateral suprasesamoidal tubercle of the femur of Stoats. The arrows indicate the location of the tubercle. Three stages were distinguished: Fully developed tubercle (*a*), visible but indistinct tubercle (*b*), and no tubercle at all (*c*).

at all. Femurs with no tubercle or indistinctly present tubercle appeared to belong to juvenile and subadult individuals, while femurs with fully developed tubercles belonged to adult Stoats (fig. 5). This method proved to be very useful in separating juvenile females from adult ones.

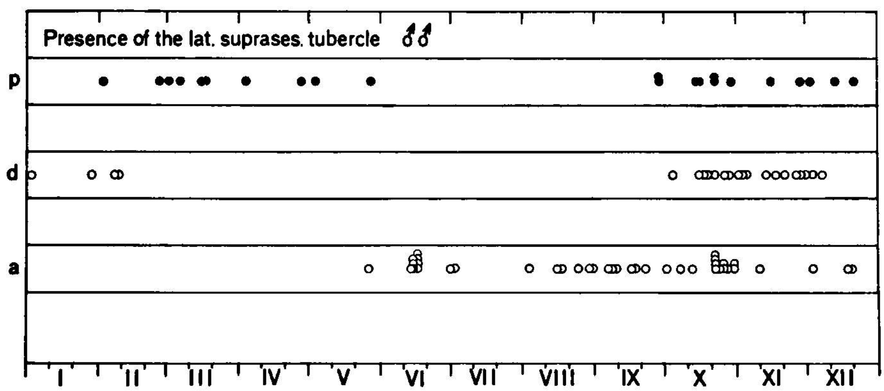

FIG. 5. Development of the lateral suprasesamoidal tubercle of the femur of 84 ♂ Stoats. *a* = tubercle absent, *d* = indistinctly present, *p* = present. Black circles represent adults, open circles juveniles and subadults.

TABLE V. Statistical data of body measurements of female Stoats

a. Total length (mm)

	juvenile		subadult		adult
m	263.00		328.95		330.88
s	136—341		301—355		301—347
s.d.	87.48		14.23		11.36
t		4.15		0.46	
p		< 0.1%		> 50%	
n	6		37		16

b. $\sqrt[3]{\text{Weight}}$ (g)

	juvenile		subadult		adult
m	4.84		5.80		5.84
s	21—241		142—251		177—239
s.d.	1.46		0.30		0.16
t		3.56		0.33	
p		< 0.1%		> 50%	
n	6		38		15

c. Tail length (mm)

	juvenile		subadult		adult
m	66.50		88.21		90.06
s	24—91		71—105		76—99
s.d.	28.78		6.95		5.33
t		3.88		0.93	
p		< 0.1%		25—50%	
n	6		38		16

d. Length of hindfoot (mm)

	juvenile		subadult		adult
m	33.50		41.46		41.94
s	17—43		37—45		39—45
s.d.	11.04		7.66		1.68
t		2.15		0.24	
p		5—2%		> 50%	
n	6		37		16

e. Ear length (mm)

	juvenile		subadult		adult
m	15.33		19.89		20.80
s	7—22		15.5—22		17—23
s.d.	6.06		1.42		1.38
t		3.90		2.12	
p		< 0.1%		5—2%	
n	6		38		15

1.2. Females:

In separating subadult female Stoats from adults the presence or absence of the lateral suprasesamoidal tubercle of the femur was used (fig. 6). As with the males the subadult and juvenile females were characterized either by the absence or indistinct presence of the tubercle, while all females with a fully developed tubercle were considered to be adult. As a matter of fact the analogy with the males in respect of sexual adulthood is not entirely valid, for first year female Stoats already participate in mating (Deanesly, 1935). But the first pregnancy occurs in about the 11th month from birth, so no basic error is included when calling Stoats of 4—11 months old "subadult". Females with open or nearly closed skull sutures were considered to be juvenile.

The composition of the female part of the population sample was thus found to be: 6 juveniles, 41 subadults and 16 adults.

1.2.5. The formation of the sagittal crest was less correlated with the condylobasal length than in the males, the correlation coefficient being 0.33. This represents, however, still a 98% probability of the correlation being significant (n = 57). Fig. 7 illustrates the correlation. As with the males a significant difference in development of the sagittal crest between young and adult female Stoats was found (table VIIIb), but no adult age groups could be separated with this age criterion.

The results of the study of *body measurements, skull measurements* and *tooth wear* did not differ from those obtained with the males (see tables V and VI).

1.2.8. Presence of clear nipple areas. Females which have lactated at least once possess enlarged and clearly distinguishable nipples (Deanesly, 1935; Taber, 1963) for a certain period of the year, usually from April till November. Those, which have not lactated, i.e. animals younger than 12 months (Deanesly, 1935), possess hardly detectable nipples. In this way 10

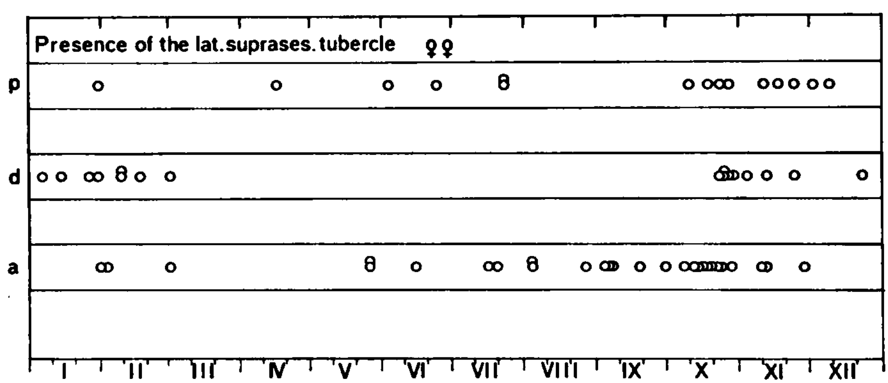

FIG. 6. Development of the lateral suprasesamoidal tubercle of the femur of 60 ♀ Stoats. *a* = tubercle absent, *d* = indistinctly present, *p* = present. Animals with a distinct tubercle were considered to be adult.

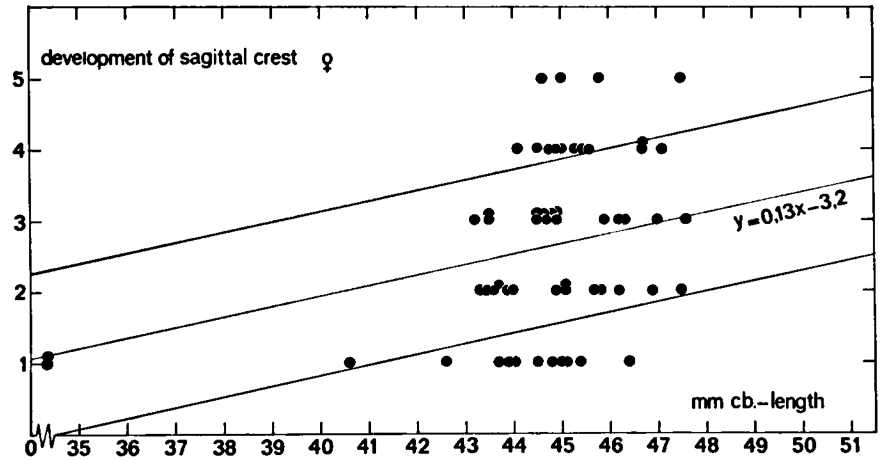

FIG. 7. Relation between the condylobasal length and the development of the sagittal crest of 57 ♀ Stoats.

animals could be distinguished as clearly over one year old. Those 10 were all clearly adult when judged by the femoral tubercle. The other 6 adult animals could not be distinguished on the presence of nipples for they were

TABLE VI. Statistical data of skull measurements of female Stoats.

a. Condylobasal length (mm)

	juvenile		subadult		adult
m	38.48		45.07		44.98
s	27.2—46.4		42.6—47.6		43.3—46.7
s.d.	8.78		0.82		1.13
t		4.25		0.32	
p		< 0.1%		> 50%	
n	5		36		16

b. Zygomatic breadth (mm) expressed as index zyg.br./cbl × 1,000

	juvenile		subadult		adult
m	560		557		574
s	568—552		520—593		547—605
s.d.	8.00		7.02		16.14
t		—		4.99	
p		—		< 0.1%	
n	2		33		15

c. Mastoid breadth (mm) expressed as index mast.br./cbl. × 1,000

	juvenile		subadult		adult
m	492		475		477
s	548—466		505—454		517—458
s.d.	28.86		10.86		14.07
t		2.37		0.53	
p		2—1%		> 50%	
n	5		33		15

d. Height of the skull (mm) expressed as index skull h./cbl. × 1,000

	juvenile		subadult		adult
m	463		385		383
s	540—399		410—355		408—364
s.d.	58.02		13.03		14.01
t		6.16		0.50	
p		< 0.1%		> 50%	
n	4		31		14

c. Postorbital constriction (mm)

	juvenile		subadult		adult
m	11.40		11.07		10.40
s	8.6—12.6		9.0—12.1		9.2—11.6
s.d.	1.20		0.69		0.70
t		0.80		2.55	
p		25—50%		2—1%	
n	4		35		14

killed in the winter months, in which time of the year the nipples have regressed (Deanesly, 1935).

No further relative age indicators were found and consequently subdivision of the adult females into age groups was not possible.

2. *Cemental layers in left canines:* (table VII, figs. 8, 9 and 10)

Since it was not possible, technically, to cut canine sections of all animals, 20 male and 17 female canines were selected. Cemental layers appeared visible as dark blue bands in a light blue surrounding.

Two presumptions were made: firstly, one cemental layer is laid down during one year (based on the results of investigations by Kleinenberg & Klevezal, 1966; Adams & Watkins, 1967; Jensen & Nielsen, 1968; McCutchen, 1969 and Klevezal & Kleinenberg, 1969, amoung others) and secondly, annuli do not disappear during the course of life (suggested by Adams & Watkins, 1967, while studying Groundsquirrels).

In table VII the results of this investigation are given. The 17 female canines were chosen at random: 6 young animals and 11 adults. The male

TABLE VII. Cemental layers in left canines of 20 ♂♂ and 17 ♀♀ Stoats.

Number of layers	Number of ♂♂	Number of ♀♀
0	5	2
1	6	7
2	5	5
3	0	1
4	2	1
5	1	0
6	1	0
7	0	0
8	0	1

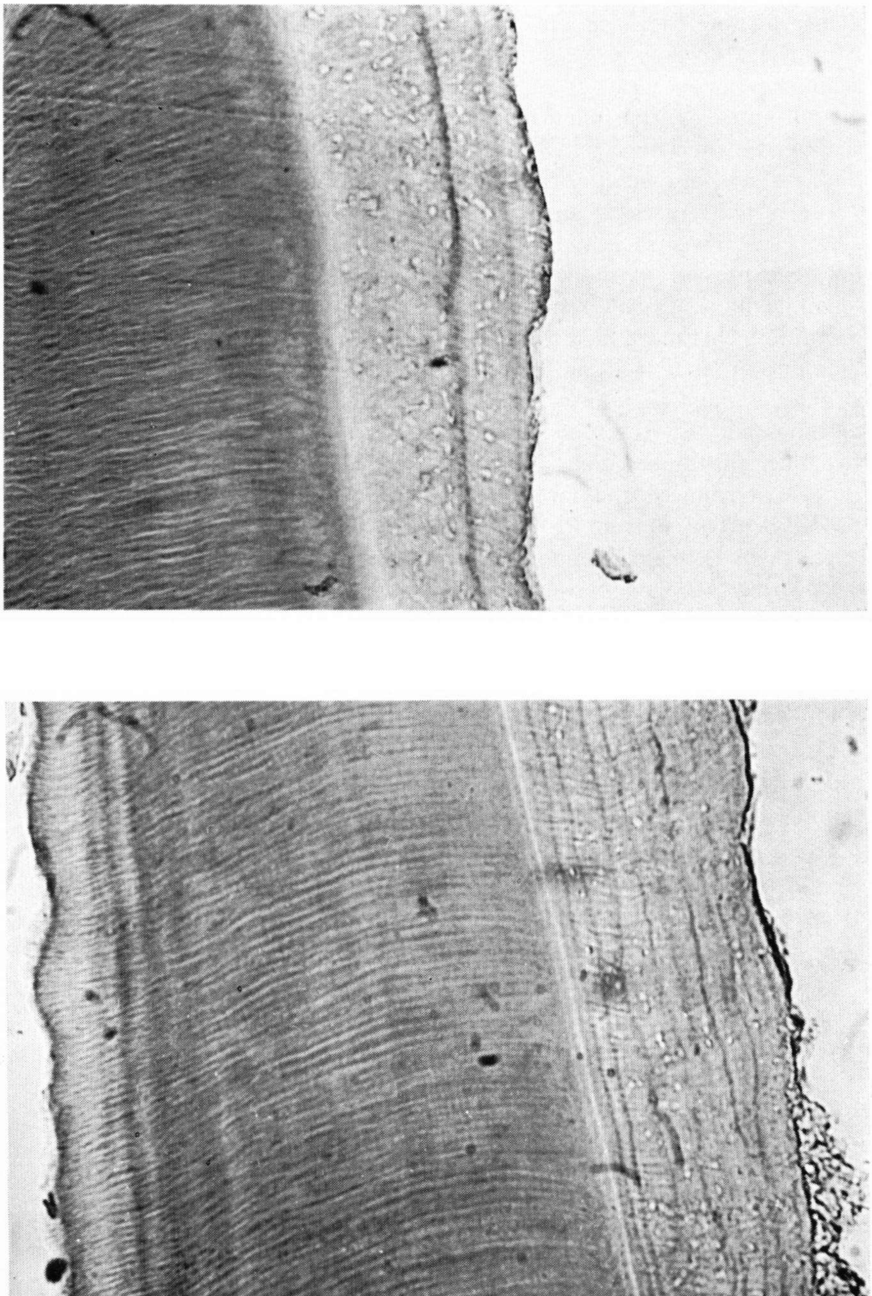

FIG. 8. Cemental growth layers in left canines of Stoats. Above ZMA. reg.nr. 8837, with two dark layers, supposedly 2 years old. Below ZMA. reg.no. 10,362, with eight dark layers, supposedly 8 years old.

canines were chosen according to mounting baculum weights, for the purpose of investigating the supposed relation of baculum weight and age.

From fig. 9, which represents the number of cemental layers plotted against baculum weights, it can be seen that these age indicators show a linear correlation up to a certain limit (4 annuli). After that no further increase of the baculum weight with increasing number of annuli was found.

When one presumes the date of birth of the Stoat to be in April — which is true in most cases — and one uses the already made assumption of one layer being deposited in the tooth cementum each year, the age of the Stoats can be expressed in months. This provides, plotted against the baculum weight, a more elegant representation of the correlation already discerned from fig. 9. One more factor, however, is needed before fig. 10 can be drawn. The more or less exact date or period of the appearance of each new cemental annulus must be known. From the subadult male and female canines it was apparent that this phenomenon occurs in the period from the end of November till the beginning of December, because from that period on subadult Stoats showed one dark layer.

More clearly than from fig. 9 it can be learned from fig. 10, that the baculum weight really is related to age up to the fourth year. This being established, it was possible with aid of weight values and killing dates (fig. 1) to make a subdivision of adult males into four age groups: the first (representing animals 1 to 2 years old) with baculum weights ranging from 32 to 39 mg, the second (representing animals 2 to 3 years old) with baculum weights ranging from 40 to 47 mg, the third (representing animals 3 to 4 years old) with baculum

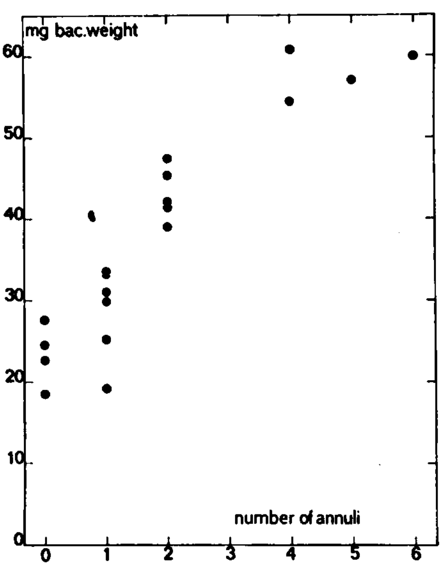

FIG. 9. Relation between the baculum weight and the number of dark layers found in the tooth cementum (presumed to be annuli) of 20 ♂ Stoats.

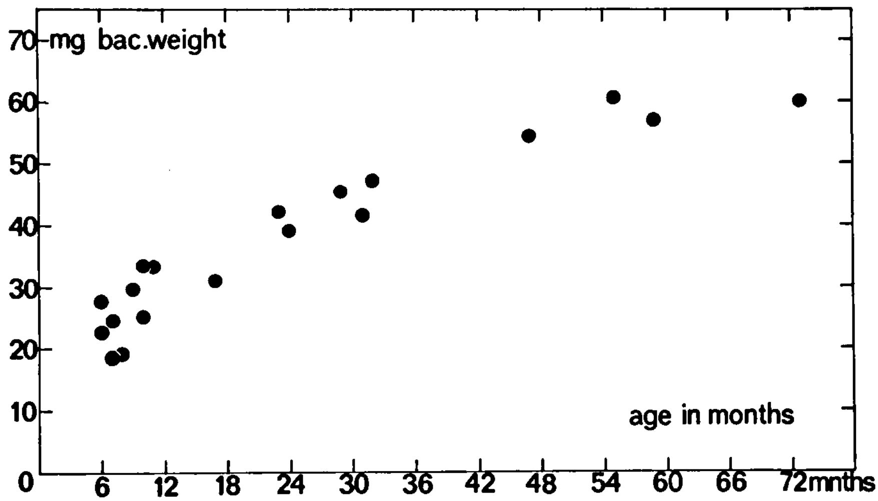

FIG. 10. Relation between the baculum weight and the age in months, based on cemental annuli and killing dates, of 20 ♂ Stoats. (For full explanation see text).

weights ranging from 48 to 55 mg and the fourth (representing animals over 4 years old) with baculum weights exceeding 55 mg.

The results of the study of the baculum protuberance supports this subdivision to a certain extent. Three of the above mentioned groups can be isolated from fig. 2: the first with baculum weights ranging from 32 to 39 mg and protuberance heights between 1.1 and 2.0 mm, the second with baculum weights ranging from 40 to 47 mg and protuberance heights between 2.0 and 2.6 mm, and the third with baculum weights over 47 mg and protuberance heights between 2.2 and 2.8 mm.

No such subdivisions could be made in the female part of the sample. However, all presumed adult females, which were treated with the tooth sectioning method, showed one or more dark layers, while subadults showed one dark layer only from December onwards.

The maximal number of dark layers encountered in the tooth cement of males was 6 (ZMA reg.nr. 8777), of females 8 (ZMA reg.nr. 10,362; see fig. 8 below).

Of the two staining fluids which were used, only Mayer's haemalun produced mostly (but not always) acceptable results. Ehrlich's haemalun did not produce any results (used by Kleinenberg & Klevezal, 1966).

3. *Conclusions of age determination.*

In tables VIIIa and VIIIb the male and female age groups which can be distinguished are set down against all relevant indicators. All values are accompanied by the necessary statistical data.

Suture closure and epiphyseal junction are useful criteria in indicating juvenile animals, while baculum protuberance and femoral tubercle are valuable indicators of adulthood.

Baculum weights proved to be substantial evidence in distinguishing adult males in age groups, while the development of the sagittal crest could not be used, although it is valuable circumstantial evidence.

TABLE VIIIa. Indicators of male age groups.

Age criterion	Age groups					
	I		II	III	IV	V
	Juv.	Subad.				
Baculum weight (mg):						
m	7.40	21.99	35.52	43.77	53.95	59.27
s	1.3—18.5	14.5—32.3	31.0—39.0	41.0—47.3	53.3—54.4	57.0—60.8
sd	6.44	4.81	2.78	2.29	0.77	1.64
t		7.44	8.49	5.73	5.66	3.33
p		< 0.1%	< 0.1%	< 0.1%	0.1—0.2%	5—2%
n	8	54	10	6	2	3
Baculum length (mm):						
m	16.20	23.06	24.64	25.08	25.85	26.30
s	8.1—24.5	19.4—25.5	23.7—25.6	23.0—26.8	25.2—26.5	25.5—27.3
sd	5.39	1.17	0.73	1.41	0.92	0.90
t		8.27	13.15	2.50	0.63	0.42
p		< 0.1%	< 0.1%	5—2%	> 50%	> 50%
n	8	54	10	6	2	3
Baculum protuberance (mm):						
m	—	—	1.78	2.40	2.50	2.57
s	—	—	1.1—2.0	2.2—2.7	2.4—2.6	2.2—2.8
sd	—	—	0.34	0.17	0.14	0.33
t	—	—		3.88	0.67	0.22
p	—	—		0.2%	>50%	>50%
n	—	—	9	6	2	3
Sagittal crest: (expressed in arbitrary units 1, 2, 3, 4, and 5)						
m	1.40	2.80	3.90	4.00	4.50	4.00
s	1—3	1—5	3—5	3—5	4—5	3—5
sd	0.80	1.08	0.68	0.82	0.71	1.00
t		11.67	2.89	0.24	0.67	—
p		< 0.1%	0.1—1%	>50%	>50%	—
n	10	51	9	6	2	3
Suture closure: (expressed in units 1, 2, and 3)						
m	1.18	3.00	3.00	3.00	3.00	3.00
Epiphyseal junction: (expressed in units 1, 2, and 3)						
m	1.00	2.88	3.00	3.00	3.00	3.00

From tables VIIIa and VIIIb the age structure of the Stoat population from the considered coastal dune region can be extracted. For this purpose a pyramid was chosen as the best way to show the results (fig. 11).

Of the males 75.9% (66 individuals) are presumed to have been less than

TABLE VIIIb. Indicators of female age groups:

Age criterion	Age groups				
	I				II
	Juvenile		Subadult		
Presence of femoral tubercle (expressed in units 1, 2, and 3)					
m	1.00		1.49		3.00
Sagittal crest (expressed in arbitrary units 1, 2, 3, 4, and 5)					
m	1.00		2.45		3.86
s	—		1—5		3—5
sd	0		1.06		0.75
t		3.45		4.55	
p		< 0.1%		< 0.1%	
n	6		38		15
Suture closure (expressed in units 1, 2, and 3)					
m	1.29		3.00		3.00
Epiphyseal junction (expressed in units 1, 2, and 3)					
m	1.00		2.92		3.00

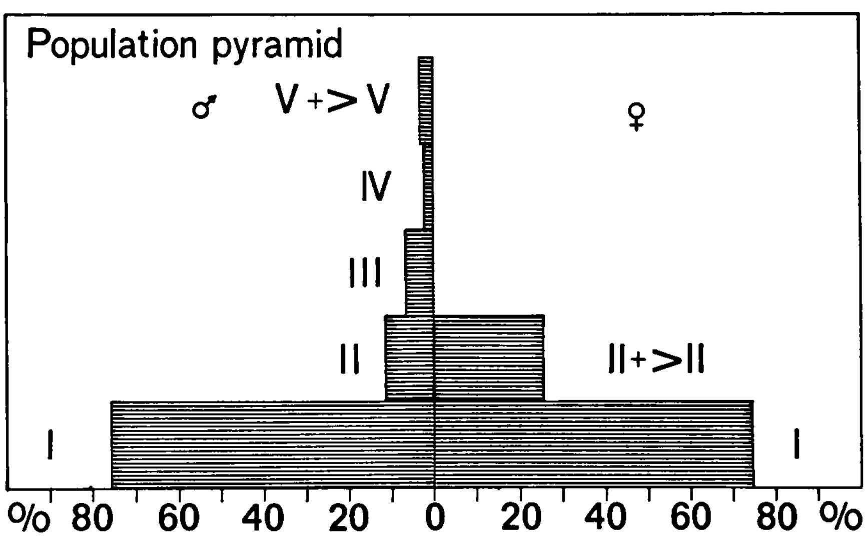

FIG. 11. Age composition of the total sample of the studied Stoat population. The roman figures represent the various age classes.

one year old (juveniles and subadults), 11.5% (10 individuals) 1 to 2 years old, 6.9% (6 individuals) 2 to 3 years old, 2.3% (2 individuals) 3 to 4 years old, and 3.4% (3 individuals) over 4 years old.

Of the females 74.6% (47 individuals) are presumed to have been under one year old and 25.4% (16 individuals) over one year old.

Of the total sample 75.3% (113 individuals) are presumed to have been less than one year old and 24.7% (37 individuals) over one year old.

THE SEXUAL CYCLE OF THE STOAT

1. Females

Extensive investigations of the sexual cycle of the female Stoat have been made by Deanesly (1935, 1943) and Watzka (1940). From these studies it can be concluded that the female Stoat has a delayed implantation of the blastocyst (an embryonic stage of two cell layers). Ovulation takes place in summer. usually involving fertilization, while implantation is held off until the following spring (February—April). When implanted the Stoat embryo takes about 8 weeks to develop. The litter size is variable: 6 to 13 (with a mean of 9) according to Deanesly (1935), 4 to 9 according to IJsseling & Scheygrond (1950), and 6 according to Deanesly (1943).

The newly born female Stoat becomes sexually adult in the summer of the same year in which it is born; it generally participates in mating and becomes pregnant. No evidence has been found of more than one pregnancy in one year, although it has not yet been established with certainty, whether there is only one ovulation or more annually.

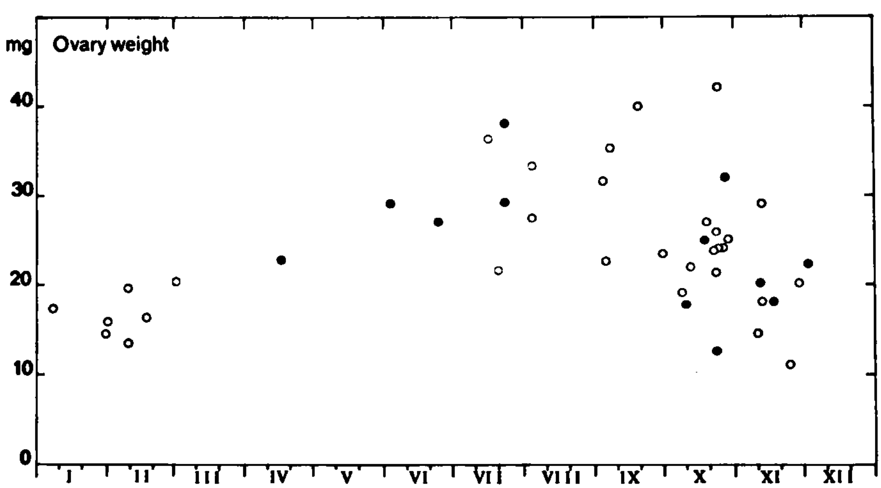

FIG. 12. Ovary weights of 43 ♀ Stoats in the course of year.

To the evidence provided by Watzka (1940) and Deanesly (1935, 1943) no new facts could be added; the increase of ovary weights in summer and fall (fig. 12), due to the increase of corpora lutea of ovulation and pregnancy, was also found by Deanesly (1935). The values found by us in the present study are much lower than those of Deanesly (1935), because the ovaries were shrunken by two years preservation in formalin.

For comparison two ovaries were sectioned and stained for microscopic examination; one adult dating from the 11th of November (ZMA reg.nr. 9934) with a high ovary weight, and one subadult from the 9th of February (ZMA reg. nr. 9273) with a low ovary weight. Although the weights differed considerably, no fundamental histological differences could be found, both showing developed corpora lutea.

The sample under study was not very rewarding in this respect: no female with implanted embryos was found, while only two showed clear signs of lactation (ZMA reg.nrs. 9249 and 9255).

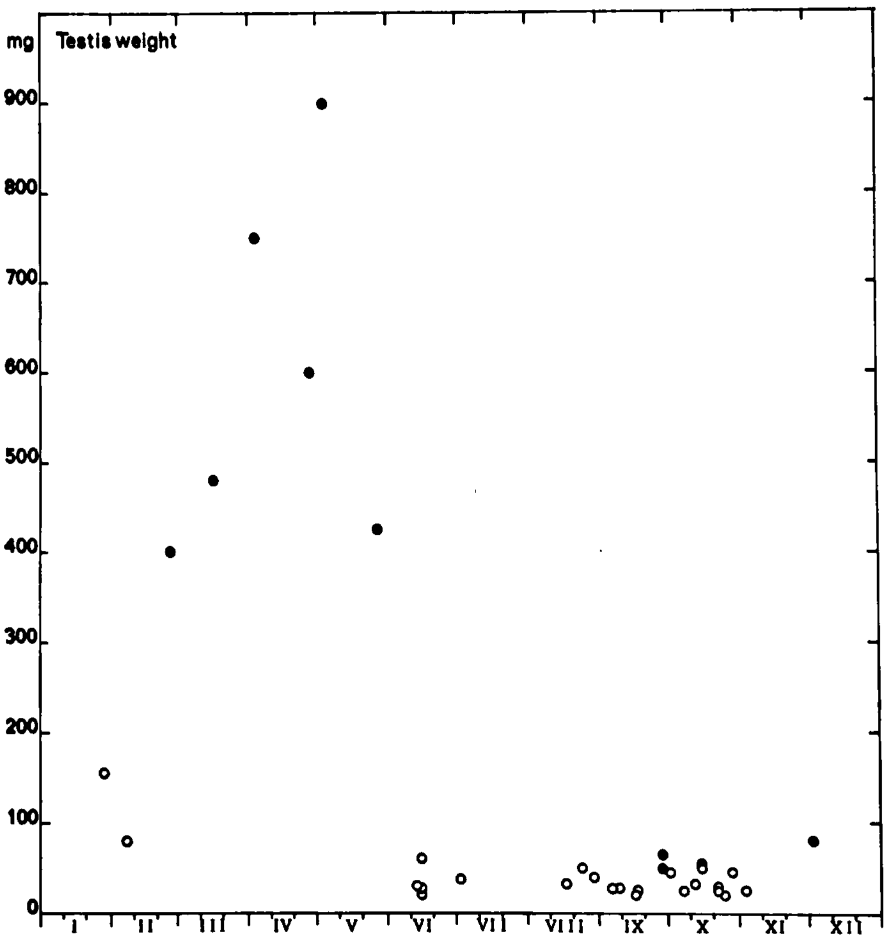

FIG. 13. Testis weights of 34 ♂ Stoats in the course of the year.

2. Males

According to Deanesly (1935, 1943) and Watzka (1940) the male Stoat unlike the female reaches sexual adulthood in the spring following the year in which it is born, remaining sexually juvenile for about 10 months. In February to March the first spermatozoids appear in the testis tubuli. They can be found there until July when the testis goes into regression. However, enough spermatozoids are left in the epididymis to allow mating to continue till September.

Testis weights taken from 34 Stoats (fig. 13) appeared to be distributed in accordance with the data given by Deanesly (1935). Almost no difference exists between the weight of regressed testes and that of juvenile ones (open circles in fig. 13), not weighing more than 80 mg at the most. Actively secreting testes reach weights of 1,000 mg or more (Deanesly, 1935).

The lengt of the testis (fig. 14) of 77 animals seems to differ from the results of the weights of the testes, showing a tendency to have a second increase in October to November. Apart from the question, whether the length of the testis is a trustworthy indicator of changing size, it must be observed, that no adult males have been killed in the months June to October, a gap in the supply of data which makes it impossible to decide in this matter. No support for the suggestion of a second sexually active period was found with the microscopic examination of 34 testis slides, all testes demonstrating regressed or undeveloped tubulus walls during the period of July to December. The tubuli seminiferi show only one or two cell layers in this period, while in the period of January to June there are five.

First spermatozoids were observed on the 28th of January (ZMA reg.nr. 10,374), although an animal of the 7th of February (ZMA reg.nr. 9543) did not appear to have them, even showing a tubulus wall that was not fully developed. The last animal which was found to possess spermatozoids in the

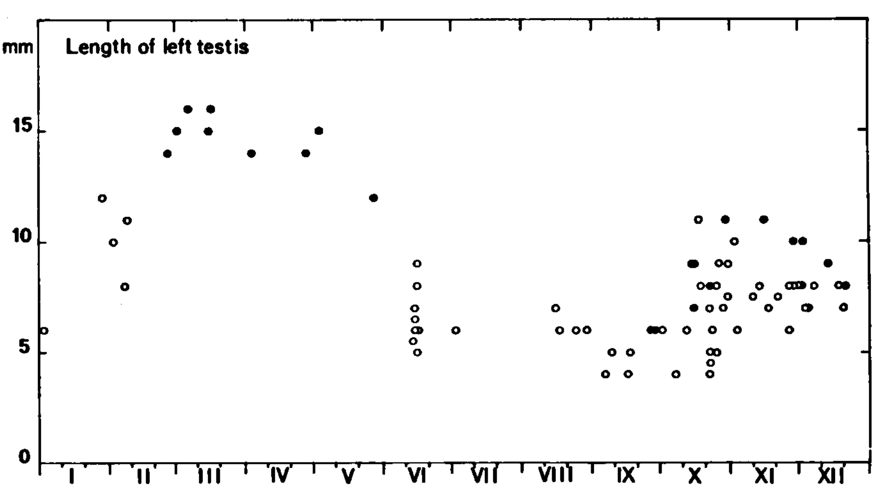

FIG. 14. Length of the testis of 76 ♂ Stoats in the course of the year.

testis, was killed on the 27th of May (ZMA reg.nr. 8781); but as was stated above, no adult males were killed during the months June to October, allowing no definite conclusions about the length of the period of spermatogenese.

Population analysis

It was determined above that the female Stoat bears one litter each year, with a supposed mean litter size of 6, while the age at which females contribute their first recruitment is one year old. In programming a hypothetical population pyramid (Quick, 1963) the following presumptions must be made: the actual composition of the total number of young at birth is 50% males and 50% females (a sex ratio of 100 : 100), and mortality does not occur, so increase of the population is unimpeded. To simplify things the male and the female segment of the population can be dealt with separately. It follows then that every male produces an offspring of 3 young males each year and every female 3 young females.

Theoretically the age composition of the male segment of a Stoat population of 7 year clases — the maximal number of annuli encountered in males was 6 — is thus expected to show a ratio of 3072 : 768 : 192 : 48 : 12 : 3 : 1, or expressed in percents 75 : 18.7 : 4.6 : 1.2 : 0.3 : 0.1 : 0.03. The actually found age composition was: 75.9% 0 to 1 year old, 11.5% 1 to 2 years old, 6.9% 2 to 3 years old, 2.3% 3 to 4 years old and 3.4% over 4 years old (i.e. 4 to 5, 5 to 6 and 6 to 7 years old) (see also table IX).

TABLE IX. Comparison of theoretically expected and actually found population composition of the male segment of a Stoat population sample.

Age class	0—1	1—2	2—3	3—4	4—7
Expected (%)	75.0	18.7	4.6	1.2	0.5
Actually found (%)	75.9	11.5	6.9	2.3	3.4

The number of young Stoats corresponds very well to the expected number, suggesting optimal breeding possibilities. The second age class, however, is substantially less numerous than could have been expected. There seems to be no apparent explanation for this occurrence, other than sampling error, for the material was collected by shooting every Stoat encountered. The number of animals used for this study is rather low, when one considers the fact that one individual represents more than one percent of the total male sample. It is therefore not inconceivable, that the differences found between the expected and the acquired age composition are based to some extent on coincidence.

The female segment could not be dealt with similarly, for it has not been possible to distinguish separate adult female age groups. The ratio 74.6% young : 25.4% adult, however, suggests a similar composition to that found with the males.

Discussion

The usefulness of the baculum as an age criterion for distinction of adult age groups is not generally accepted. Hooper & Ostenson (1949) and Friley (1949) used baculum dimensions to classify adult River Otters (*Lutra c. canadensis*), but did not test its validity otherwise. Other authors, however, limited themselves to using the baculum as a criterion to distinguish juveniles from adults, not being able to extend its use for further distinction (e.g., Wright, 1947, with *Mustela frenata*). One great advantage in studying the age structure of Stoats is the fact, that the Stoat produces only one litter in a more or less fixed period each year. The age study of a great many other animals, for instance Weasels (*Mustela nivalis*) and Otters (*Lutra lutra*), is complicated by the fact that more than one litter may be born each year, while in other cases breeding takes place all the year round.

Elder (1951), studying known age ranch Mink (*Mustela vison*), stated that it was not possible to distinguish adult Minks in age groups by use of the baculum weights, because the overlap between the subsequent groups was too great. The authors of the present paper are of opinion that for Stoats this difficulty can be overcome if one makes allowance for the precise killing dates. All Stoats having been born in a fixed period of the year, an animal with a certain baculum weight killed on for instance the 15th of June should be distinguished easily from animals killed on approximately the same date, but with higher or lower baculum weights, although there may be an overlap between the total range of the baculum weights of the various year classes. An overlap of the baculum weights of subsequent age classes is likely to exist too in the material studied here. The ranges of the baculum weights of each age class, therefore, must not be taken too strictly, but merely as rough values, because the quantity of the studied material was rather poor.

The presence of growth layers in the teeth and the periodical aspect of it has been subject of various methods of study, e.g. by cutting thin slices of the tooth and polishing the surface to allow study under refracted light, or as was done in the present study, by histological treatment of the tooth. Various animals from different mammalian orders have been dealt with in this way (Sergeant, 1967; Klevezal & Kleinenberg, 1969).

All methods, however, came to the same conclusion, that these layers are laid down once a year. This was proved beyond doubt by way of marking and recapturing of the animals or by known age animals in captivity.

It has not, however, been proved for Stoats and no evidence was available for the assumption that the cemental layers of Stoats are in fact annuli. Part of the investigation presented here and in particular the value of the baculum weight as a criterion to classify adult age groups, is based on this assumption being true.

SUMMARY

1. The age composition of a Stoat population sample of 150 animals (87 males and 63 females) from a coastal dune region of the Netherlands was analyzed. Different relative age indicators were used. For the distinction between sexually adult and sexually immature males the presence or absence of a proximal baculum protuberance was used. Of the considered indicators for males the baculum dimensions, the presence or absence of the lateral suprasesamoidal tubercle of the femur, and the development of the sagittal crest of the skull proved to be more or less useful. The baculum weight was used to classify adult age groups. Animals not fully grown were separated on the criterion of open skull sutures and a state of non-junction of the epiphyses of long bones. Indication of female age was achieved by use of the presence or absence of the lateral suprasesamoidal tubercle of the femur. Also the presence or absence of clear nipple areas and the development of the sagittal crest were useful.

The investigation concerning the development of the sagittal crest contributed fresh evidence for the fact that this development is dependent on the size of the skull, and not as was stated by Reichstein (1957) directly linked with sex, although in general males have bigger skulls and as such stronger developed crests.

2. To test the results acquired by the use of relative age indicators, some 40 left canines of different animals were prepared and coloured for microscopic examination of cemental growth layers, which were presumed to represent an indication of absolute age. Although no real evidence of this fact was available (other than references about various animals on this subject), is was considered useful to compare the results with those acquired with relative age indicators. The number of cemental annuli appeared to correspond to a certain limit with the weight of the baculum. Till presumably the fourth year the increase of the baculum weight was directly correlated with the increasing number of annual cemental layers. After that the number of annuli increased while the baculum weight did not. Based on this presumed evidence a further subdivision of the adult males was made, resulting in four age groups, the last being a compilation of the eldest animals.

Female adult age groups could not be separated.

3. The sexual cycle of both male and female Stoat was examined. The results appeared to be in accordance with the results of Deanesly (1935, 1943).

4. With the results of the investigations a hypothetical population composition was programmed, which has been compared with the actually found age composition. Only minor differences appeared to exist between theory and findings.

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