which time 55.0% of the adult females captured were pregnant. Although the data are not yet entirely conclusive, there is an indication that the percentage of females pregnant is inversely proportional to the prevailing population density. This phenomenon has been demonstrated under laboratory conditions (Calhoun, 1949; Clarke, 1955), and in natural conditions in muskrat populations (Errington, 1954).

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ANATOMICAL VARIATIONS OF THE SPINE IN THE HORSE

BY ROBERT M. STECHER

ABSTRACT: The vertebral counts of the thoracic, lumbar and sacral spines of 190 horses and of the sacral and lumbar spines of 256 horses and classified into 9 species are given and the variations are shown. The cervical spine always had 7 vertebrae. While 18 is the usual number of thoracic vertebrae, 17 were found in 18 and 19 in 11 of 190 specimens. Nineteen thoracic vertebrae were found in only 11 of the specimens but of these 11 instances, 9 occurred among 32 spines of the Prjevalsky horse. The domestic horse, Shetland pony, zebras, Arabian horses and hybrids normally have 6 lumbar vertebrae, the donkeys and hemiones have 5 but exceptions were found in all classes. The Prjevalsky horse has 5, or 6 equally divided. It may be proper to think of the Prjevalsky horse as having normally 6 lumbar vertebrae with a high incidence of dorsalization of L1. The sacra usually have 5 vertebrae, this number having been counted 176 times, but 4 vertebrae were counted 49 times and 6 vertebrae 9 times. Caudal vertebrae are often fused with the sacrum making a single functional unit. If such fused caudal vertebrae and transitional sacro-caudal vertebrae are counted as parts of the sacra, of 52 horses with 5 lumbar vertebrae, 2 had 4, 30 had 5, 16 had 6 and 4 had 7 sacral segments; of 180 horses with 6 lumbar vertebrae, 18 had 4, 110 had 5, 44 had 6 and 8 had 7 sacral segments. Horses with 5 lumbar vertebrae had longer sacra, average 5.41, than horses with 6 lumbar vertebrae, average 5.23. The shortest sacra were found in Shetland ponies, horses, Arabians and Prjevalsky horses. The longest sacra were found in Grevy zebras, zebras, donkeys and hemiones.

Variation in one portion of the spine results in compensating changes in the neighboring areas.

This is a statistical study concerning numerical variation of the vertebrae in

the spine of the horse. It is based on data from 256 skeletons. In 190 of these the entire vertebral column is considered but in the remainder, 66 specimens, data are limited to the lumbar and sacral regions. The material comprises horse bones macerated in the field by the weather, fresh skeletal material from a horse butcher, and specimens examined personally in numerous zoological museums in America and Europe. Because of special interest in this subject, information on the Prjevalsky horse has been collected through three correspondents, and data on one skeleton were taken from the literature (Salensky, 1907). The source of this material, its extent and its variety are given in Table 1. This study is made to provide background information desirable for further studies of the lateral joints in the lumbar spine of the horse and of ankylosing diseases of the spine of the horse (Stecher and Goss, 1961).

The following discussion will be easier to understand after a word of explanation about the classification and terminology used. Common names have been employed but with great care to insure consistency and scientific accuracy. Races and species have been grouped together when such grouping is justified by the relationship of the animals and when the numbers of specimens in each group are too small to provide significant data separately.

TABLE 1.—*Source of material studied*

Institution	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
SPECIES																		
Domestic horse	24	7	8	4	4	2	2	1		3	6	5					28	94
Shetland pony	3				1				2		1						1	8
Zebra	30	8	3		3	3	3	5	2			3						60
Grevy zebra	9	4	2						2									17
Hybrid mule	5		2														1	8
Ass	6		2		3		1	2	2								2	18
Hemione	5	2	1						1									9
Arabian	8	1						1										10
Prjevalsky horse	7	2							5	2			4	1	10	1		32
	97	24	18	4	11	5	6	9	14	5	7	8	4	1	10	1	32	256

INSTITUTION

1. American Museum of Natural History, New York.
2. United States National Museum, Smithsonian Institution, Washington, D. C.
3. Museum of Comparative Zoology, Harvard University.
4. School of Veterinary Medicine, University of Pennsylvania, Philadelphia.
5. Chicago Museum of Natural History.
6. Cleveland Museum of Natural History.
7. Musée Royal de Congo Belge, Tervuren, Belgium.
8. Institut Royal des Sciences Naturelle de Belgique, Brussels.
9. Laboratoire d'Anatomie Comparée, Muséum National d'Histoire Naturelle, Paris.
10. Zurich Zoological Society, Zurich.
11. Veterinas Anatomische Institut am Veterinarische Medicinische Fakultät der Universitat, Zurich.
12. Hochschule für Bodenkultur, Vienna.
13. British Museum, London.
14. Institut für Agricultural Zoologie, University of Halle.
15. Zoological Institute, Leningrad.
16. Prjevalsky's Horse, Salensky.
17. Private collection.

The term horse is used here as a general term to designate the genus *Equus*. The domestic horse, the typical species, is represented here by specimens gathered in Wyoming, those so identified by the horse butcher and specimens so labeled in zoological museums. The Shetland pony has been tabulated separately from the domestic horse, where he really belongs, because he is so reliably identified by recognizable characteristics in life and by the size of the skeleton. The Grevy zebra has also been removed from the numerous other races and varieties of striped horses because it can be accurately identified in life and because it is so labeled in anatomical collections. All other zebras have been grouped together, correctly or not, because of confusion as to exact anatomical differentiation, a wide diversity of synonyms applied to them and the very small numbers of specimens in some of the categories. The term hybrid, as used here, refers to the progeny of a horse ordinarily considered to have 6 lumbar vertebrae, in other words, a domestic horse crossed with an animal ordinarily thought to have only 5 lumbar vertebrae. In 6 instances this was a donkey and the hybrid was a mule; in 2 instances it was an Arabian horse and the hybrid was an Arabian hybrid. The term donkey refers to all domesticated asses of Africa, Europe or America. Hemione refers to several wild asses, the true hemione of Asia, the Onager and the Kiang. Arabian horses are accepted as such when so labeled. The Prjevalsky horse is also accepted as so labeled.

The material has been arranged in the following order into three groups. The first group is composed of horses usually thought to have six lumbar vertebrae and include domestic horses, Shetland ponies, Grevy zebras, other zebras and the hybrids. The hybrids are included here because the hereditary factor for 6 lumbar vertebrae is dominant over the factor for 5 lumbar vertebrae (Frechkop, personal communication). The second group includes the horses with 5 lumbar vertebrae, the donkeys and the hemiones. The third group, composed of the Arabian horses and the Prjevalsky horses, is intermediate because in the material here studied they were found to include specimens with both 6 and 5 lumbar vertebrae. They are usually described as having 5 lumbar vertebrae (Carter, 1923 and Salensky, 1907).

The lumbar and sacral portions of the spine will first be described. The definitions of them used in this study are taken from Schultz and Straus (1945) and are quoted as follows:

"Lumbar vertebrae = the vertebrae between the thorax and the sacrum, bearing no ribs or possessing no lateral masses participating in the formation of sacral foramina. It is especially mentioned that if the transverse processes of a vertebra articulate even extensively with the ilia, but do not form sacral foramina together with the following vertebra, the former segment is regarded as a lumbar one. If the transverse and costal elements of a vertebra meet (with or without fusion) the corresponding parts of the adjoining vertebra lateral to an intervertebral foramen, thus forming a continuous articulation with the

ilium, the vertebra is counted as a sacral whenever these conditions exist bilaterally, and as a lumbo-sacral, if unilaterally.

"Sacral vertebrae = the vertebrae composing the sacrum and possessing intervertebral and sacral foramina ringed completely by bone in the adult. Actual osseous fusion is not necessary, but contact between the sacral wing portions of adjoining vertebrae, lateral to the sacral foramina, must exist in either a bony or cartilaginous state. The number of sacral vertebrae equals half the number of sacral foramina plus one. The number of sacral foramina, however, at times can differ on the two sides in consequence of asymmetrical formations at either end of the sacral region. Such transitional lumbo-sacral or sacro-caudal vertebrae are classified by half segments."

An example of a spine with 5 lumbar vertebrae, characteristic of the donkey and hemione, is shown in Plate I A. The tips of the lateral facets were damaged in maceration. A spine with 6 lumbar vertebrae characteristic of the domestic horse or zebra is shown in Plate I B. This specimen also shows a sacrum with 5 vertebrae. One unusual anomaly, seen only once in this series of 256 specimens, an animal with 7 lumbar vertebrae, was found in a Grevy zebra and is shown in Plate I C. This animal was immature because the epiphyseal plates have not yet fused with the vertebral bodies. A sacrum with 4 sacral vertebrae and an attached caudal vertebra from a horse is shown in Plate I D. That the last vertebra of this specimen is a caudal vertebra is shown by notches along the edges of the sacrum instead of foramina completely surrounded by bone. Plate II A shows a sacrum with 5 vertebrae. The epiphyseal plates have not yet fused. Plate II B shows the sacrum of a donkey with 6 vertebrae. The first caudal segment is attached to the sacrum in this specimen.

In this series of 256 horses, 13 examples of asymmetrical sacra were found. Eleven specimens had 4½ segments, Plate II C, and 2 had 5½ segments, Plate II D. Four occurred in the domestic horse, 3 in zebras, 1 in a Grevy zebra, 2 in the donkey, 2 in Arabian horses and one in an Arabian hybrid. Each of these sacra had one sacro-caudal vertebra and an additional specimen from a domestic horse had one lumbo-sacral vertebrae. Plate III shows the sacrum of this domestic horse which had 5 lumbar vertebrae, one lumbo-sacral vertebra and 4 sacral vertebrae. The transverse line in the illustration is an artifact due to a fracture of the sacrum occurring during maceration.

Seven cervical vertebrae were invariably found when they were counted so this portion of the spine needs no further comment. Eighteen thoracic vertebrae is the general rule, having been found in 160 of 190 spines in which thoracic vertebrae were counted. Seventeen thoracic vertebrae were found 18 times, 19 in 11 instances and 18½ once. In 2 of 18 cases, one a zebra and one a donkey, 17 thoracic vertebrae occurred with only 5 lumbar vertebrae, making an unusually short thoraco-lumbar spine of only 22 body vertebrae (thoracic and lumbar vertebrae). The other 16 instances with 17 thoracic vertebrae had 6 lumbar vertebrae or 23 body vertebrae. These were seen in 4 horses, 6 zebras, 4 Arabians, one Arabian hybrid and one mule. Twenty-two body vertebrae

were found once each in a zebra and a donkey. Twenty-three body vertebrae were not uncommon having been found 51 times, 24 were found 136 times and 25 once. Nineteen thoracic vertebrae were always associated with only 5 lumbar vertebrae. This combination occurred 11 times, once in a zebra, once in a hemione and in 9 of 32 Prjevalsky horses. Although data on the lumbar and sacral areas of the spine are given in Table 2, the same data are included in Table 4 and will be discussed later.

In Table 3 are assembled data on larger sections of the spine and averages of the thoraco-lumbar, lumbo-sacral and thoraco-lumbo-sacral areas are given for 190 horses of different species. As can be seen, the hemione and the donkey have the shortest spines or at least the spines with the fewest vertebrae. The hemione has the shortest spine, averaging 23.11, 9.77 and 27.77, respectively, for the thoraco-lumbar, lumbo-sacral and thoraco-lumbo-sacral areas. The donkey has slightly more, averaging 23.09, 10.32 and 28.23. The domestic horse, Shetland pony and the zebras were all very nearly alike, their average varying from 23.80 to 24.00, 10.64 to 10.77 and 28.56 to 28.85, respectively. The Grevy zebra qualified as having the longest spine of the genus with an average of 24 thoraco-lumbar vertebrae equal in length to those of the Shetland pony, 10.91 lumbo-sacral compared to 10.77 in the zebra and 29.0 thoraco-lumbo-sacral compared to 28.85 in the Shetland pony. The hybrids, although small in number, are intermediate, the result being due no doubt to the occurrence in this small series of 2 specimens with 17 dorsal and one with 5 lumbar vertebrae. The Arabian horses and Prjevalsky horses are also intermediate.

Table 4 is similar to Table 2 but it gives detailed information on the lumbar and sacral regions from 256 spines. It differs from Table 2 in giving information from 256 spines instead of 190 spines. Similar numerical variations to those noted above are given. A tendency toward compensation is seen because specimens with a smaller number of lumbar vertebrae often have a larger number of sacral vertebrae or a larger number of attached caudal vertebrae.

The significance of attached caudal vertebrae is uncertain. They may be developmental peculiarities, anatomical anomalies or pathological lesions. It was shown in a previous study that fusion of the caudal vertebrae can occur at a young age before maturity is attained (Stecher and Goss, 1961). Caudal vertebrae which have fused with the sacrum as well as asymmetrical or transitional vertebrae function as part of the sacrum and have the effect of increasing its length. Although not correct anatomically, the effective number of sacral segments as determined by including the added caudal and asymmetrical vertebrae ankylosed to the sacrum is shown in Table 5. In general, those horses with 5 lumbar vertebrae have a larger number of sacral segments than those with 6 lumbar vertebrae. The average number of sacral segments of animals with 5 lumbar vertebrae was 5.41 segments compared to 5.24 segments in animals with 6 lumbar vertebrae. Two animals with 5½ lumbar vertebrae had 5.00 sacral segments. The association of short lumbar vertebrae and a larger number of sacral segments was found in all species except the Grevy zebra,

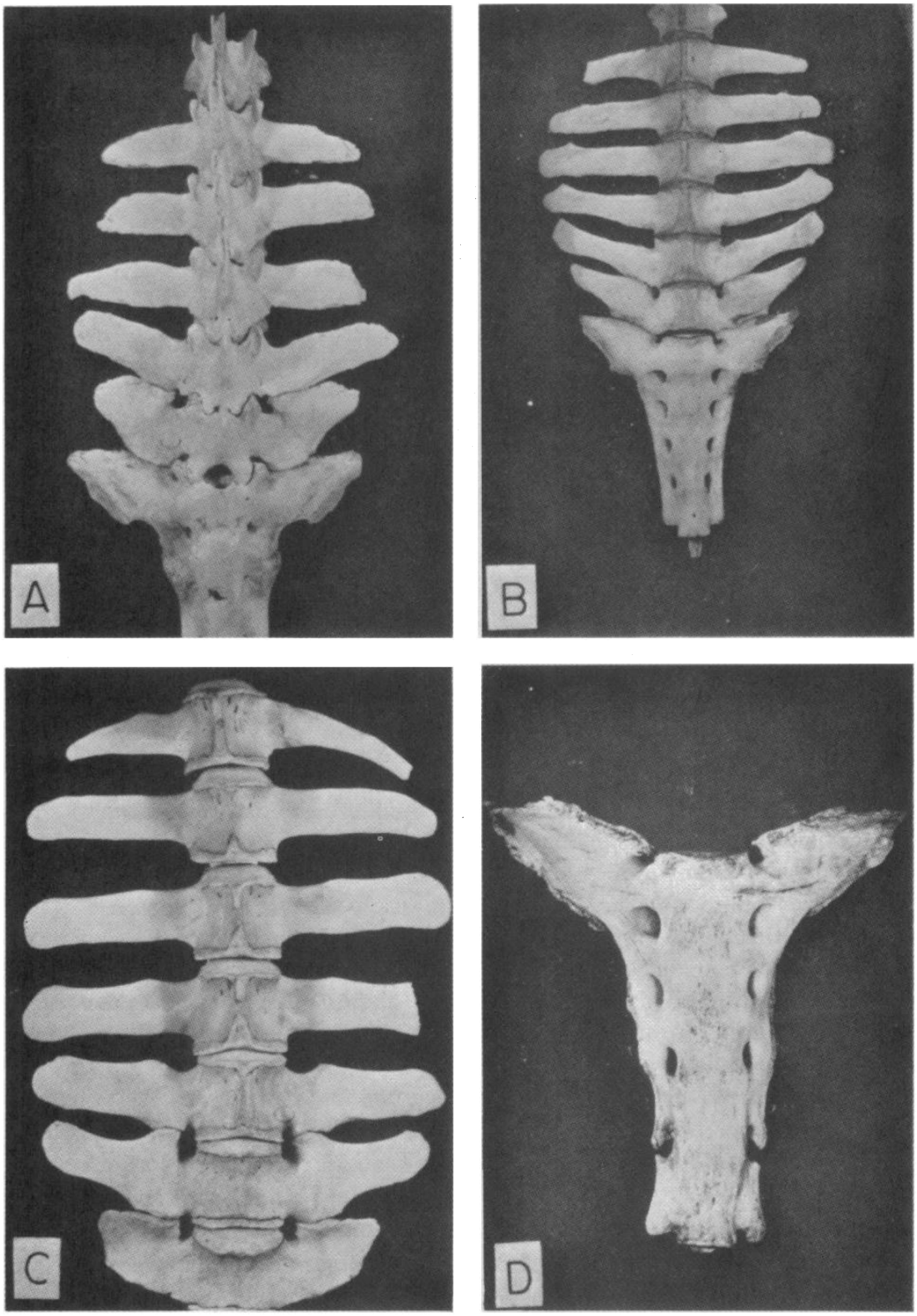

PLATE I

A.—Dorsal view of the lumbar spine of a domestic donkey showing the last dorsal vertebrae, 5 lumbar vertebrae and part of the sacrum.

the hybrids and the Arabian horses, species which had only one or three animals with 5 lumbar vertebrae. Considering the sacra and attached transitional or caudal vertebrae as one unit, the Shetland pony had 5.00, the Prjevalsky horse 5.07, the domestic horse 5.11, the Arabian horse 5.12, the hemione 5.33, the zebra 5.47, the Grevy zebra and the donkey 5.53.

DISCUSSION

All domestic horses, donkeys, asses and zebras are members of the genus *Equus*. They are characterized as follows: the domestic horse, whether a large draft horse, a small Shetland pony or an intermediate type, has a long turned-down mane, a forelock, a hair-covered tail, short ears, long legs, broad hooves and a small head. The domestic horse whinnies.

The domestic donkey and the wild asses, including hemiones, kiangs and onagers, are closely related to each other if not of the same species. They are gray or brown in color, have a stand-up mane, a thoracic stripe, often a crucial stripe across the shoulder, a donkey tail with long hair only on the distal half, narrow hooves and long ears. They do not have a forelock. These animals bray.

Zebras are easily distinguished by their stripes. The Grevy zebra is the largest and the most nearly horselike of the zebras. Its stripes are narrow and numerous, are concentric around the tail, do not extend onto the belly, and there is both a dorsal and a ventral stripe. The tail is nearly horselike with more long hair than the donkey tail.

The Burchell, Grant and Böhmi zebras are closely related to each other or are slight variants based upon their geographical distribution. They have fewer and wider stripes, often alternating with faint or shadow stripes. The stripe pattern is characteristic. The stripes meet across the belly, and there is a dorsal stripe. These animals have a donkey-type tail. The mountain zebra and the Hartman zebra differ slightly, being smaller, and have stripes across the back, producing a gridiron, which do not cross the belly. A dorsal stripe is lacking. Because of their close similarity, all of the zebras, except the Grevy zebras, are considered as one group. The cry of a zebra is intermediate between a whinny and a bray.

The literature contains little information about anatomical variations in the number of vertebrae of the horse. Sisson and Grossman (1955) state that the vertebral column of the horse contains 7 cervical, 18 thoracic, 6 lumbar, 5 sacral and 21 caudal vertebrae without any mention of numerical differences between

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B.—Ventral view of the lumbar spine of a domestic horse with the last dorsal vertebra, 6 lumbar vertebrae and the sacrum. The sacrum is composed of 5 vertebrae.

C.—Ventral view of the lumbar spine of a Grevy zebra with 7 vertebrae. This is very unusual, being the only example showing 7 lumbar vertebrae seen among 245 specimens. That he is immature is shown by the persisting epiphyseal plates.

D.—Ventral view of the sacrum of a domestic horse with 4 sacral segments. Attached to the sacrum by firm bony ankylosis is the first caudal vertebra identified so by the intervertebral notches instead of sacral foramina.

TABLE 2.—*The number of thoracic, lumbar and sacral vertebrae showing also transitional vertebrae and ankylosed caudal vertebrae. Vertebral columns of 190 horses are complete except that the sacra are missing from 10 spines. Half units indicate transitional vertebrae; plus units indicate ankylosed caudal vertebrae*

		D17	18	18½	19	L5	5½	6	7	S?	S4	4½	4+1	4+2	5	5½	5+1	5+2	6	6½	6+1
Domestic horse	55	4						4			1		1		2						
			50			6									4		2				
								44		3	8	2	2		20	1	8				
				1			1								1						
Shetland pony	7		7					7			1		1		4		1				
Zebra	49	7				1		2		1									1		1
								4										3			1
			41			3		1							1		1	1	1		
								37		1	3	3	4	2	10		13	1			
					1	1											1				
Grevy zebra	14		14			1											1				
								12		2		1	1		2		4	1	1		
									1						1						
Hybrid mule	6	2						2					1		1						
			4			1									1						
								3				1			1			1			
Ass	11	1				1						1									
			10			8									4		2		2		
								2									2				
Hemione	9		8			8					1		1		2		2	1	1		
					1	1					1										

TABLE 2.—*Continued*

Arabian	7	4						4			1						1	1	1					
			3				1										1							
								2				1	1											
Prjevalsky	32		23				7										4		3					
								16			1	3					10		2					
					9		9				1						7		1					
	190	18	160	1	11		48	1	140	1	10	19	9	11	2		77	2	44	8		6		2

TABLE 3.—*The number of thoraco-lumbar, lumbo-sacral, and thoraco-lumbo-sacral vertebrae as well as transitional lumbo-sacral vertebrae shown as half units. The vertebral columns of 190 horses are complete except that the sacra are missing from 10 spines*

Form	Total	Thoraco-lumbar					Lumbo-sacral								Thoraco-lumbo-sacral							
		22	23	24	25	Avg	Unknown	9	9½	10	10½	11	11½	12	Avg	26½	27	28	28½	29	29½	30	Avg
Domestic horse	55		10	45		23.82	3			17	3	31	1		10.64		2	18	2	29	1		28.56
Shetland pony	7			7		24.00				2		5			10.71			2		5			28.85
Zebra	49	1	9	39		23.80	2			13	3	27		4	10.77			15	3	28		1	28.67
Grevy zebra	14		1	12	1	24.00	2			3		7		2	10.91			1	1	8		2	29.04
Hybrid mule	6		3	3		23.50				3		3			10.50		2	2		2			28.00
Ass	11	1	8	2		23.09			1	6		4			10.32	1		6		4			28.23
Hemione	9		8	1		23.11		3		5		1			9.77		2	6		1			27.77
Arabian	7		5	2		23.29	1			3		3			10.43			6					28.00
Prjevalsky	32		7	25		23.71	2			14		16			10.53			10		20			28.66
	190	2	51	136	1	23.59	10	3	1	66	6	97	1	6	10.48	1	6	66	6	97	1	3	28.40

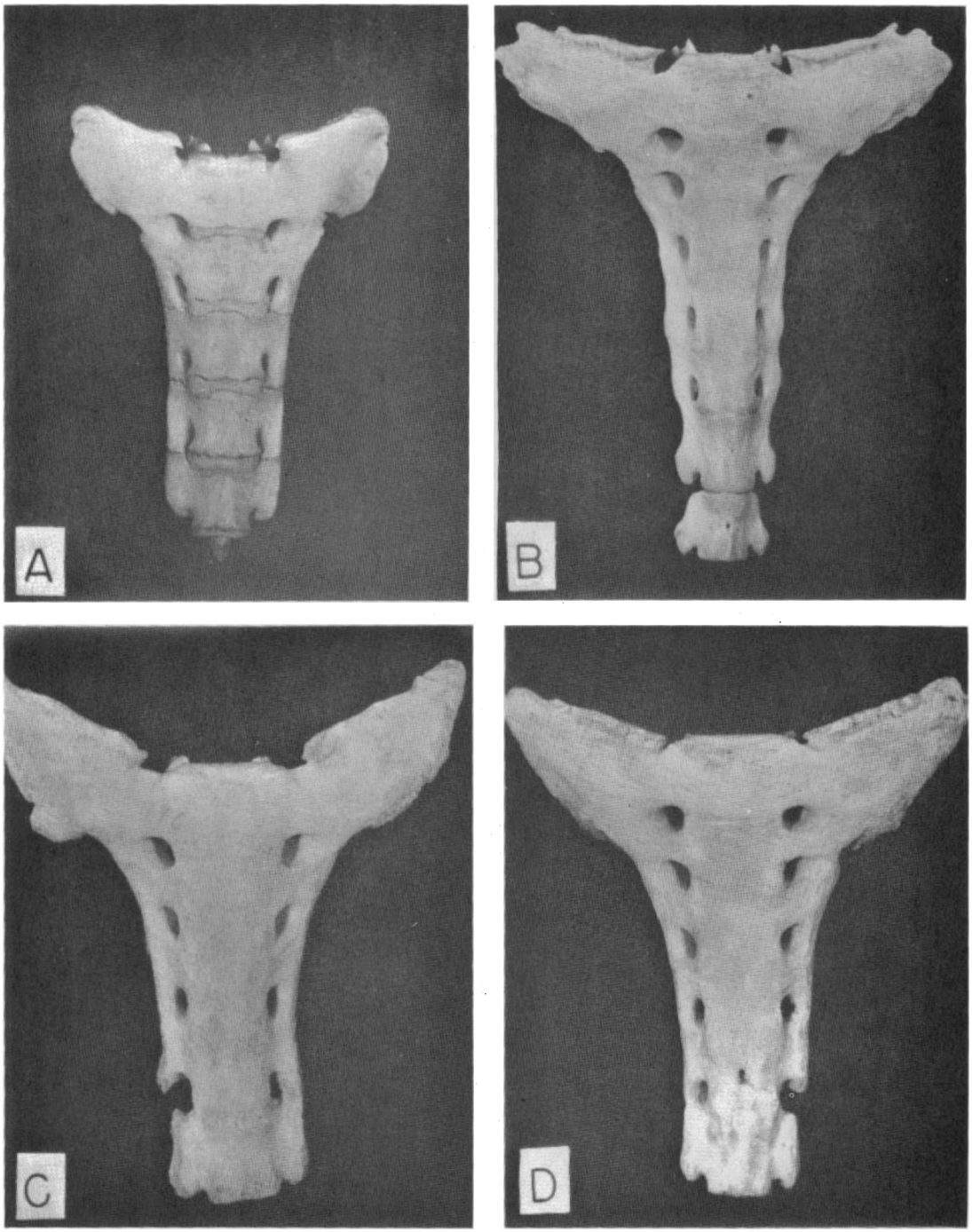

PLATE II

A.—Ventral view of the sacrum of a zebra with 5 sacral segments. This is a young animal as indicated by the epiphyseal plates which have not yet become fused to the vertebral bodies.

B.—Sacrum of a donkey with 6 sacral and an attached caudal vertebra.

C.—An asymmetrical sacrum of an Arabian hybrid with 4½ sacral segments. Actually there are 4 right sacral and 5 left sacral segments. The last segment is a sacro-caudal vertebra.

D.—Another asymmetrical sacrum of a pure Arabian horse with 5½ sacral segments.

TABLE 4.—*The number of lumbar and sacral vertebrae including transitional vertebrae shown as half units and attached caudal vertebrae as plus units in the entire series of 256 horses. The sacra are missing from 22 spines*

Form	Total	L5	5½	6	S–	S4	4½	4+1	4+2	S5	5½	5+1	5+2	6	6+1
Domestic horse	94	5								3		2			
			2				1			1					
				87	12	8	2	7		43	1	14			
Shetland pony	8			8		1		1		5		1			
Zebra	60	5								1		2	1		1
				55	3	5	3	3	3	21		11	4		2
Grevy zebra	17	1								1					
				16	2		1	2		4		5	1	1	
Hybrid mule	8	1								1					
				7			1	1		2		2	1		
Ass	18	14			1		2			5		2	1	3	
				4						2		2			
Hemione	9	9				2		1		2		2	1	1	
Arabian	10	3								2				1	
				7	2	1	1			1	1	1			
Prjevalsky	32	16			1					11		4			
				16	1	3				10		2			
Asymmetrical sacra							11				2				
Sacro-caudal fusion								15	3			50	9		3
	256	54	2	200	22	20	11	15	3	115	2	50	9	6	3

species or numerical variation between individuals of the same species. In discussing native horses of North Africa, Carter (1923) states that ". . . the Arabian has only five lumbar vertebrae while, with rare exception, there are six in other horses." "The donkey also has five lumbar vertebrae." Carter states further that a famous Morgan sire was found at post-mortem to have only 5 lumbar vertebrae and similar other cases have been reported. This, he thought, suggested that the Morgan horse is of Arabian extraction. The Prjevalsky horse, according to Salensky (1907), normally has but 5 lumbar vertebrae, an opinion he seems to have drawn from examination of only one skeleton.

The author recalls no statement in the literature concerning the number of vertebrae of the various zebras. It seems to be the same as in the horse. No clear statement has been found about the lumbar spine of the mule, a cross

between the domestic horse and a donkey. Frechkop (personal communication) states the character of 6 lumbar vertebrae is dominant over the character for 5 lumbar vertebrae. Six lumbar vertebrae can be expected in the usual hybrids of the domestic horse or the zebra crossed with the donkey or the Arabian horse.

The classification of most of these horses is reasonably reliable and depends upon the labels on the specimen boxes, the geographical source of the animal and, in some cases, the recorded history. The classification of the domestic horses, the Shetland ponies, the different types of zebras and the wild asses seems accurate. The immediate parentage of donkeys and Arabian horses is often doubtful because of the similarity in size and form of their hybrids to their parents and because of the well-known carelessness, naïveté, and guile of horsetraders and horsemen. This was revealed when the author was invited by the horse butcher to examine a "mule" whose spine was to be given to him. The "mule" had a foal at her side. She also had 5 lumbar vertebrae and was therefore classified as a donkey. Arabian stallions are often bred to domestic mares in America with the resulting temptation to call their progeny Arabian horses. The Prjevalsky horse was known to run with feral horses in the wild and some of the first Prjevalsky horses captured were described as hybrids.

Examination of the tables shows variations in the number of vertebrae in all regions of the spine except the cervical region and in all species of the horse. Most of them are true anatomical variations in the same species. Some of them

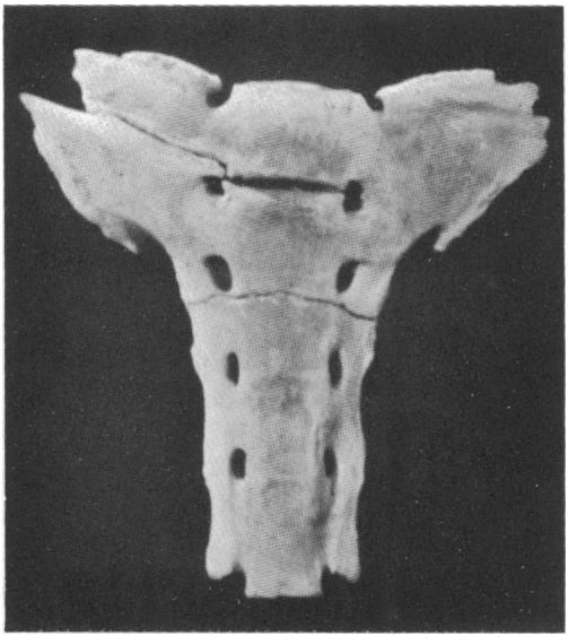

PLATE III

A third asymmetrical sacrum with 4½ segments. In this case there are 4 right and 5 left sacral vertebrae. The transitional segment in this case is a lumbo-sacral vertebra. This specimen was fractured during maceration.

TABLE 5.—*The functional length of the sacra, ascertained by adding the number of true sacral vertebrae, the transitional vertebrae and the attached caudal vertebrae*

Form	Total	5L	5½L	6L	S?	4S	5S	6S	7S	Average S in 5L	Average S in 5½L	Average S in 6L	Total average
Domestic horse	94	5					3	2		5.40			
			2				2				5.00		5.11
				87	12	8	52	15				5.09	
Shetland pony	8			8		1	6	1				5.00	5.00
Zebra	60	5					1	2	2	6.20			
				55	3	5	27	14	6			5.40	5.47
Grevy zebra	17	1					1			5.00			
				16	2		7	6	1			5.57	2.53
Hybrid mule	8	1					1			5.00			
				7			4	2	1			5.57	5.50
Ass	18	14			1		7	5	1	5.54			
				4			2	2				5.50	5.53
Hemione	9	9				2	3	3	1	5.33			5.33
							2	1		5.33			
				7	2	1	2	2				5.20	5.25
Prjevalsky	32	16			1		12	3		5.20			
				16	1	3	10	2				4.93	5.07
All horses		54			2	2	30	16	4	5.41			
			2				2				5.00		
				200	20	18	110	44	8			5.23	
Total	256	54	2	200	22	20	142	60	12				5.25

are true species differences. The four specimens of the domestic horse with 17 dorsal vertebrae constitute true anatomical variations from the normal 18. The same can be said for the six specimens with 5 lumbar vertebrae, two which were Morgan horses. The Shetland pony showed remarkable stability as did the Grevy zebra although one specimen of the latter with 7 lumbar vertebrae, the only one of the entire series, is a rare variation. The zebra was relatively unstable with numerous variations in all areas of the spine except the neck. It is tempting to think that the one hybrid with 5 lumbar vertebrae and two donkeys with 6 lumbar vertebrae were mislabelled and might be transposed. The hemione showed remarkable stability, the one specimen with 19 thoracic vertebrae being the only variation. The Arabian and the Prjevalsky horse showed the greatest variations in the thoracic and lumbar region. Of 7 speci-

mens of the thoracic vertebrae in the Arabian horse, 4 had 17 vertebral segments and 3 had 18 vertebral segments. In the lumbar region 3 Arabian horses had 5 lumbar vertebrae and 7 had 6. Of those horses with 6 lumbar vertebrae, 4 had 17 thoracic vertebrae. It can truthfully be said that the Arabian horse is short coupled, as horsemen call it, or has a reduced number of body vertebrae. This is evidence that these horses are purebred instead of hybrids as suggested above.

Among the Prjevalsky horses, 23 had 18 thoracic vertebrae and 9 had 19. This is a peculiarity of this horse, having been found only twice otherwise among the 190 skeletons examined. In the lumbar region 5 segments and 6 segments were equally divided. In the sacral region, five vertebrae and six vertebrae were each found 16 times. This suggests that many of the Prjevalsky specimens examined were hybrids but the large proportion of horses with 19 dorsal vertebrae suggests that this animal had dorsalization of the first lumbar vertebrae rather than a short lumbar spine.

The sacral region shows marked variation in all species of horse. The widest variation from 4 sacral to 6 + 1 was found in the zebra and animals with 6 sacral vertebrae were found among the Grevy zebras, the donkeys and the hemiones. The transitional form with sacro-caudal segments was not found among Shetland ponies, the Grevy zebras, the hybrids, the donkeys, the hemiones or the Prjevalsky horses. This is probably determined more by the small number of specimens in these series than upon a true anatomical difference. The zebra had by far the largest proportion of specimens with attachment of the caudal segments to the sacrum, this peculiarity having been found in 28 out of 49 skeletons. It was found 5 times among 9 hemiones.

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ACTIVITY OF SMALL MAMMALS AS RECORDED BY A PHOTOGRAPHIC DEVICE

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ABSTRACT: Activity of small mammals in relation to time of day and various weather conditions was studied during April, May, October and November, 1960, in grassy vegetation located one mile south of Haslett, Ingham County, Michigan. The activity was recorded by means of a two-box photographic apparatus. One box, containing a camera with a synchronized flash, was set on one side of a surface runway used by small mammals. The other box, containing climatological instruments, a millimeter rule, and a clock, was set on the opposite side of the runway. This latter box was arranged in such a way that when an animal activated the apparatus by stepping on a treadle set in the runway, a photograph was then taken of the animal against a background of the dials of the instruments.

The photographic records showed that the shorttail shrew, *Blarina brevicauda,* and the meadow vole, *Microtus pennsylvanicus,* were the most common mammals in the habitat studied. The records were analyzed statistically with respect to the environmental conditions that were present when each of these species was photographed in the runways. Both species were active in runways chiefly at night, although in autumn the shorttail shrew was more active in daylight than the meadow vole. In general, activity of both species showed poor correlation with changes in such environmental factors as temperature, humidity, barometric pressure and periods of precipitation. Activity, therefore, was influenced principally by an intricate interplay of all factors combined.

One of the problems faced by the ecologist when investigating the activity of small mammals is the extreme difficulty in observing accurately their natural habits without disturbing the environment. In recent years photography has been employed to a progressively greater extent to obtain such information. The object of this study was to determine the use made of surface runways by small mammals in relation to time of day and various climatic factors. A photographic device much like that employed by Pearson (1959) in California was used.

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