DEFORMATIONS OF VERTEBRAL COLUMN IN BREEDING RABBITS

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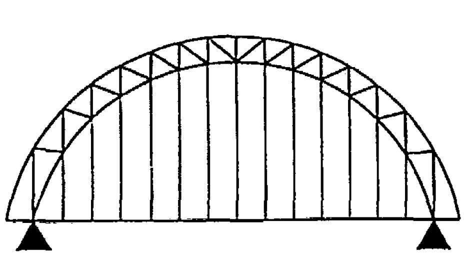
Abstract - Vertebral columns of female and male breeding rabbits kept in conventional cages or in a group housing systems have been investigated by spot checks anatomically and radiographically with regard to its deformations. It should be proved whether the male and female rabbits get deformations at the vertebral column depending on the housing system and the possibility of locomotion.
The observations show that the bucks had no deformations, whereas the does had.
The causing factors has become evident: frequence and degree of deformation are dependent on the cage size. A lack of room provokes deformations by flat sitting as well as the systemic hypoplasie of bony tissue caused by deficiency of locomotion. Reproduction provokes deformations of the vertebral column, too, causing alterations in the static-dynamic forces of trunk construction as well as a high need and metabolism of calcium.

INTRODUCTION

Figure 1: Scheme of a parabolic bow-string-bridge (NICKEL et al., 1992)

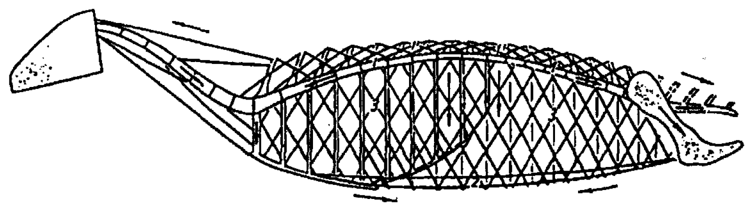


The trunk construction of quadrupeds is built like a parabolic bow-string-bridge (SLIJPER, 1946 and 1947 ; KUMMER, 1959; NICKEL et al., 1992). The loaded traffic lane of a parabolic bow-string-bridge is not based on supporting pillars, but it is bent with its ends between a bow arching over the lane to which it is hung up by vertical junctions (figure 1).

On the analogy of this bow-string-concept at the trunk of quadrupeds the bearing bow is composed of the dorsal-convex thoracic and lumbar vertebral column as well as the pelvis and the associated muscles. The bow is bent by a string consisting of the sternum, the linea alba and the *m. rectus abdominis*. Rips, *m. transversus abdominis* as well as the *mm. obliquii abdominis* are hung up to the bow.

Thoracic and lumbar vertebral column represent a complete and consolidated construction unit which takes upon itself the function of the bearing bow loaded with its own weight and that of the bowels. The abdominal part of the bending string consists of the linea alba, the muscles of the abdominal wall and their aponeurosises. It is flexible and contractible and for that purpose it acts as a complete elastic aponeurosis whereas in the thoracic region it is represented by the sternum, the rips and the intercostal muscles which make up a much stronger foundation. The bow is braced by a pressure resistant lower belt (intervertebral discs, vertebral bodies and *lig. longitudinale ventrale*) and an upper belt (small intervertebral joints as well as ligaments and muscles communicating between the spinous processes) (figure 2).

Figure 2 : Scheme of the static trunk construction (NICKEL et al., 1992)



The vertebral column and its surrounding truncal muscles represent a balanced and according to functional features instructed system which protects, supports and acts as a flexible, slightly compressible rod, through which the propelling force generated by the pelvic limbs is transmitted to the rest of the body (EVANS and CHRISTENSEN, 1979). It is characterized by load capacity, elasticity and agility. The vertebral column serves the trunk as a supporter for the cavities of the body as well as a receiver and transferer of the shove produced by the hindlimbs forward to the forelimbs with the slightest possible lost of energy. Alterations proceeding at any part of the system will take effect on the whole system (LOEFFLER, 1967).

MATERIAL AND METHODS

The radiological and anatomical investigations have been carried out with ZIKA-rabbits, a meat line with the ability of rapid growth. Table 1 gives a survey about amount of animals, sex, housing systems and animals's age of radiological studies.

Table 1 : Animals

group	amount	sex	housing	age of radiological studies
1	20	male	cage 1*	c. 12 months
2	10	female	cage 1*	9 - 16.5 months
3	20	female	cage 2**	2 - 4 years
4	12	female	1.-3. month cage 1* from 4. month 3-c-s***	3, 18, 22, 26, 33 months

*) cage 1: size 50 x 70 x 40 cm (length x breadth x height) plastic slatted floor, remaining walls out of wire grates

**) cage 2: size 60 x 40 x 32 cm (l x b x h) floor and walls out of wire grates

***) 3-c-s= 3-compartment-system : 1. compartment for does' retiring, 2. compartment for young and adult rabbits and the 3. compartment for young rabbits = litter boxes

Roentgenograms have been made in laterolateral and ventrodorsal planes.

Radiological alterations of the vertebral column can be classified in three kinds of deviation from the normal-anatomical vertebral column curve, namely in the horizontal plane (scoliosis) and in the median plane (lordosis and kyphosis).

The alterations have been classified in three degrees:

light (+) with small, significant (++) with distinct and high significant (+++) with heavy deviations of the affected sections of the vertebral column in a parahorizontal resp. paramedian plane. Furthermore scoliosises were differentiated in simple scoliosis, i.e. a simple deformation of a section, s-shaped scoliosis, i.e. a main- and counter-curve, and a tripel-scoliosis, i.e. a threefold curve in the concerning section of vertebral column.

The rabbits were killed by slaughtering and the vertebral columns were dissected and mazerated.

RESULTS

The established deformations have manifested exclusively in the thoracic section of the vertebral column, in the course of which scolio-kypho-lordosis (9x), scoliosis (5x), lordosis and scolio-kyphosis (each 2x), kyphosis and scolio-lordosis (each 1x) have been found. The results from the radiological examinations are summerized in table 2. It shows clearly that the female caged rabbits contrary to the males have more frequent and to a higher degree deformations of the vertebral column.

The male rabbits had no positive findings. The female rabbits from the 3-c-s showed in 2 of 12 cases light pathologic curves (1x lordosis, 1x scolio-kyphosis). These alterations have already manifested at the age of three months as they were transferred to the 3-c-system: they had been kept in small cages during the first three months of life.

All animals show alterations only at the thoracic section with the exception of one animal which has one altered lumbar vertebra, too. 17 of 20 cases present a scoliosis: 5 of them a simple, 8 a s-shaped and 4 a tripel-scoliosis. Lordosises and kyphosises are represented 12 times each. The table shows that 9 animals have three kinds of all possible deformations at the same time, 3 animals have two and 8 have one kind of deformation. In case of combination of two or three kinds of pathological curves 9 animals show at the same region of the thoracic vertebral column both scoliosis and one or even both possible deformations in dorsoventral direction. In 6 cases scoliosis appears together with kyphosis and lordosis, in 2 cases with kyphosis and in one case with lordosis.

The results show that mainly the middle third of the thoracic vertebral column is affected by scoliosis, in heavy cases the whole thoracic vertebral column. Lordosises manifest more frequent at the caudal, kyphosis preferably at the cranial section of the thoracic vertebral column.
In a follow-up investigation rabbits of group 4 were roentgenized at different stages of life - see table 1. The positive rabbits show light pathological curves of the thoracic vertebral column which could already be registered at the age of three months.
Each radiological examination afterwards showed the same result, that means there was no deterioration or expansion of the process.
Morphological alterations of the vertebrae in the deformed sections were wedged vertebrae and/or altered spinous processes in form and direction. In kyphotic regions spinous processes are separated with wide spaces in between, whereas in lordotic regions they are pushed together so that the free ends of neighboured spinous processes are in contact with each other.

Table 2 : Survey about the radiological alterations

group	amount	m/f	housing	without findings	s	l	k	s+k	s+l	skl*
1	20	m	cage 1	20						
2	10	f	cage 1	6	3		1			
3	20	f	cage 2	6	2	1		1	1	9
4	12	f	3-c-s	10		1		1		
	62		altogether	42	5	2	1	2	1	9

* (s = scoliosis, k = kyphosis, l = lordosis, s+k = scoliokyphosis,
s+l = scoliolordosis, k+l = kypholordosis, skl = scoliokypholordosis)

DISCUSSION

Summarizing the results the following aspects arise :

1) Under identical circumstances concerning feeding, cage-housing and other stable conditions the rabbits of group 1 and 2 show in so far big differences in vertebral column alterations as the male rabbits all have been free of any alteration, whereas the female rabbits of the same age have shown light deformations of the thoracic vertebral column in 4 of 10 cases.
2) The roentgenograms of the female rabbits (group 3), housed in cages of 60 x 40 x 32 cm, show by two thirds (14 of 20 rabbits) deformations of the vertebral column: 5 lightly, 6 significantly and 3 highsignificantly altered.
3) Two of twelve animals from the group housing system (group 4) showed light alterations already at the age of 3 months. Up to that day they had lived in cage housing. The alterations, however, did not proceed during the following 30 months of group housing, nor in location nor in degree. Whether these alterations have a congenital or an acquired aetiology, especially with regard to the breeder's cage housing of the first three months, never can be cleared.
4) All positive animals show alterations at the thoracic vertebral column. 17 of 20 rabbits have a scoliosis, that is combined with deformations in dorso-ventral direction in 12 of these cases.

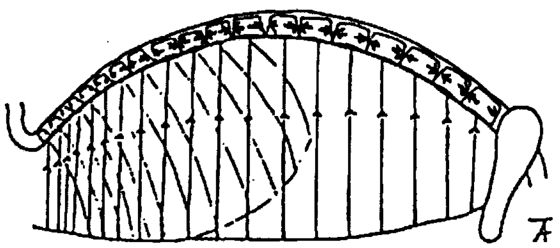
The exhibited results will be discussed in regard to the causality as well as to the relevance of animal protection.
First of all the fact surprises that the deformations have manifested in the thoracic vertebral column. But concerning oneself with the static construction of the rabbit's trunk in resting carriage the following characteristics turn out to be remarkable :

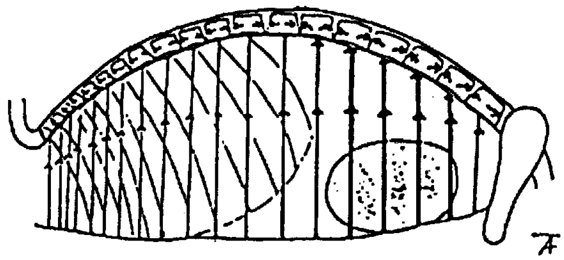
1. A significant dorsal-convex bow of thoracic and lumbar vertebral column ;
2. A thoracic vertebral column constructed from very little vertebrae and at the same time a lumbar vertebral column whose vertebrae increase in size and firmness from one to its next in cranio-caudal direction ;
3. steeply set pelvis.

In conventional cage-housing with poor height rabbits often remain in a behavioural-morphological altered "flat sitting". Then the animal's back is not arched in dorsal-convex direction, but it is ventrally flatted or even pressed through. This behaviour pattern leads to an unphysiological loading of the vertebral column which is regarded as being cage dependent accessory to the vertebral column deformation. This carriage may also be compared with the analogous resting carriage of humans leading to extension resp. shrinkage of the holding apparatus of the vertebral column.

An essential loading for the female rabbits is given by the weight of the gravid uterus. An average gravidity with 8 foetuses will bring an additional bodyweight of nearly 500 g: average foetal weight of 50 g= 400 g plus 100 g uterine additional organ weight. In the case of a gravidity with 18 foetuses there will even be an additional bodyweight of nearly 1000 g, i.e. 20% additional bodyweight for an average female rabbit that weighs 5000 g. Through the increasing bodyweight especially in the caudal section of the body its centre of gravity as well as its static-dynamic forces will be displaced caudally. Recurring to the bow-string-concept the following hypothetic explanation results :
Figure 3 shows the forces of the bow-string-construction. In the not gravid rabbit tensile forces of the string act on the vertebral column and will be turned over pressure forces from vertebra to vertebra of the bow.
In the gravid rabbit with a higher bodyweigth from 10 to 20% because of its gravid uterus much higher tensile forces (fig. 4: thick arrows) may be expected to influence first the lumbar vertebrae. Secondly they will be turned over to pressure forces and conducted from vertebra to vertebra in both cranial and caudal direction. In the caudal region of the vertebral column these forces take effect on big lumbar vertebrae as well as on the sacrum and the pelvis which are consolidated by the iliosacral joints. The steep position of the pelvis as noteworthy continuation of the bow-construction may act as an additional stabilisation of the bow. The conduction of the pressure forces to the cranial direction of the vertebral column principally means a conduction to continually in size decreasing thoracic vertebrae. Those are just slightly fixed by the moveable basis of the shoulder joints. In case the pressure forces exceed the carrying capacity of the bony basis and of the compensative mechanisms by the holding apparatus of the vertebral column, a contortion of the bow arises around its longitudinal axis, comparably to an overloaded parabolic bow-string-bridge. The contortion of the vertebrae out of the middle of the axis leads them into a paramedian plane. A scoliosis results. Most of all, this hypothesis is supported by the fact that 17 of 20 positive female rabbits show scoliosises of different degrees.

Figure 3 : Tensile and pressure forces in the non-gravid (left) resp. the gravid (right) rabbit (drawings made by A. Falter)





An exclusively caged rabbit with little possibility of locomotion suffers a systemic hypoplasia of the bony tissue, especially of the spongy (ROTHFRITZ et al., 1992) but even of the compact one (DRESCHER, 1989).
By the tensile forces the gradually increasing bodyweight of the gravid rabbit has an effect just on this hypoplastic bony tissue which at the same time is still confronted with modelling processes finishing the procedure of thickness growth.
In the sixth month of life the rabbit is confronted with those metabolic changes which repeat every month with each new pregnancy.
The investigations make evident the influence of locomotion on the vertebral column :
Extreme conditions of rabbit housing (cage 2: 60 x 40 x 32 cm) provoke high significant alterations. Ameliorated cage conditions (cage 1: 50 x 70 x 40 cm) lead to minimal deformations. Housing conditions in the proven 3-c-system with group housing, however, do not provoke any deformations of the vertebral columns of the rabbits in these investigations. As for as that goes it is demonstrated that the influence of locomotion on the bony tissue is a main factor for the development and preservation of a normal-anatomical vertebral column.

Lactation and foetal bone development taking place at the same time during the second half of pregnancy provoke a very high need of calcium. Possibly the hypoplastic bony tissue gets into a negative calcium balance.

There are four factors provoking a deformation of the rabbit's vertebral column :

1. longtermed "flat sitting" because of poor cage height,
2. systemic hypoplasia of the bony tissue because of deficiency in locomotion,
3. caudale dislocation of the body's centre of gravity as well as a change in the static-dynamic forces of the trunk construction caused by the weight of the gravid uterus,
4. high calcium need caused by gravidity and lactation at the same time.

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Wirbelsäulenverkrümmungen bei Zuchtkaninchen - Weibliche und männliche Zuchtkaninchen, die in konventionellen Käfighaltungen bzw. in einem Gruppenhaltungssystem gehalten worden waren, wurden stichprobenartig auf Wirbelsäulenverkrümmungen röntgenologisch und anatomisch untersucht. Dabei sollte geprüft werden, ob abhängig von unterschiedlichen Haltungs- und Bewegungsbedingungen die weiblichen und männlichen Zuchtkaninchen Verkrümmungen der Wirbelsäule aufweisen. Die Befunde zeigen, daß die männlichen Tiere keine Verkrümmungen aufwiesen, wohingegen die weiblichen Kaninchen positive Befunde erkennen ließen. Es wurde deutlich, daß die Häufigkeit und der Grad der Veränderungen von der Käfiggröße abhängt, die Haltungsfehler wie "flaches Sitzen" sowie eine systemische Knochengewebshypoplasie durch Bewegungsmangel bedingt, sowie von der Reproduktion, die Veränderungen der statisch-dynamischen Kräfte der Rumpfkonstruktion sowie einen hohen Kalziumbedarf und -stoffwechsel bei gleichzeitig stattfindender Trächtigkeit und Laktation bedingt.
