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Studies on muscular topography and meat properties of beavers (*Castor canadensis*) caught in Tierra del Fuego, Chile

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Summary

In 1946, 25 pairs of Canadian beavers were released in the Argentinean part of Tierra del Fuego. In the last decades the population increased, with negative consequences for the forest in the Chilean part of Tierra del Fuego. Reducing the numbers of beavers by hunting / trapping will result in production of furs and meat as a side-effect. The aim of this study was to generate data on muscular topography and meat characteristics of beavers in Chile and to compare these with findings on *Castor fiber*.

Body mass, carcass mass and carcass yield (mean values ± standard deviation; n = 25) were 14.13 ± 5.02 kg, 6.79 ± 2.54 kg, and 48.07 ± 2.45 %, respectively. The contribution of hind legs, M. longissimus and front legs to the total carcass mass was 25.17, 8.05 and 11.86 %, respectively.

Chemical composition of muscle tissue (n = 10) was 75.75, 22.46, 0.62, 1.12 and 0.34 % for moisture, crude protein, fat, ash and carbohydrates, respectively.

Abkürzungen: AOAC = Association of Official Analytical Chemists; L* = Luminance; a* = red-green colour value; b* = yellow-blue colour value

Schlüsselwörter: Biber, Fleischqualität, Anatomie.

Zusammenfassung

Untersuchungen der Muskeltopographie und der Fleischqualität des Bibers (*Castor canadenis*) aus dem Gebiet Tierra del Fuego (Chile)

Im Jahr 1946 wurden 25 Biberpaare im argentinischen Teil von Feuerland ausgesetzt. Die Population hat sich in den letzten Jahren stark vermehrt, mit negativen Auswirkungen auf den Waldbestand auch des chilenischen Teils von Feuerland. Bei einer Reduktion des Biberbestandes durch Bejagung bzw. Fallenstellen ist die Fell- und Fleischgewinnung ein Nebennutzen. Das Ziel der vorliegenden Studie war, Informationen bezüglich Muskeltopographie und fleischrelevanter Parameter chilenischer Biber zu erhalten und diese mit Daten von *Castor fiber* zu vergleichen.

Die Körpermasse (n = 25) betrug 14,13 ± 5,02 kg, die Masse der Karkasse 6,79 ± 2,54 kg (48,07 ± 2,45 % der Körpermasse), der Anteil an der Masse der Karkasse betrug für die Hinterextremitäten 25,17 %, den M. longissimus 8,05 % und die Vorderextremitäten 11,86 %.

Die chemische Untersuchung der Muskulatur (n = 10) ergab einen Gehalt an Wasser von 75,75 %, Rohprotein 22,46 %, Fett 0,62 %, Asche 1,12 % und Kohlenhydraten von 0,34 %.

Introduction

Characteristics of the beaver and his impact on the ecosystem

Beavers are herbivores and the second largest rodent species, with a total length (including tail) of up to 130 cm, and a life body mass of up to 30 kg. 2 species are recognized, *Castor fiber,* Linné 1758 and *C. canadensis,* Kuhl 1820. However, macroscopic differences are only small (SCHWAB, 2002). Populations are spread over Europe, Asia and America. The typical habitats are small rivers, where beavers build the well-known lodges. Beavers are noted for their ability to fell trees and build dams. Through these activities, the characteristics of the habitat are substantially changed, as the proportion of wetlands and open water in the forest landscape increases, and slow-running stream sections emerge. For Sweden, it was demonstrated that this re-design of the environment had a positive effect on fish species diversification (HAGGLUND and SJÖBERG, 1999). Beavers are known to be selective foragers, preferring aspen, willow, maple, birch trees and various shrubs, such as hazel. However, this selective foraging is more pronounced in the near shoreland (JENKINS, 1980), and does not necessarily cause a fauna-shift towards non-preferred tree species (DONKOR and FRYXELL, 1999). In the 18th and 19th century, beavers were eradicated in many European regions, but in the past century translocation programmes led to the re-establishment of the beaver in various regions. Active management of these protected wildlife animals is needed to avoid or minimize conflicts with man and his economic activities (PAGEL, 1994; NOLET and ROSELL, 1998). However, the establishment of beavers in regions where they never were indigenous may cause detrimental changes in the ecosystem, as is the case for the Chilean regions Tierra del Fuego

Tab. 1: Body mass, carcass mass and carcass yield of 25 beavers caught in Tierra del Fuego, Chile

	Body mass (kg)	Carcass mass (kg)	Carcass yield (%)
Mean values ± standard deviation	14.13 ± 5.02	6.79 ± 2.54	48.07 ± 2.45
Minimum and maximum values	6.34 - 22.0	2.9 - 11.12	42.15 - 51.6

Tab. 2: Carcass mass and meat cuts of beavers caught in Tierra del Fuego, Chile (mean values and relative amounts; n = 25)

	Mass (kg)	Percentage
Carcass	6.793	100.00
Hind legs	1.710	25.17
M. longissimus	0.547	8.05
Filet (M. iliopsoas)	0.149	2.19
Abdominal muscles and subcutaneous fat	0.933	13.74
Front legs	0.806	11.87
Trimmings and fat	1.243	18.30
Skeleton	1.405	20.68

Tab. 3: Chemical composition of muscle tissue of beavers (mean value ± standard deviation; n = 10), in g/100g

Moisture	75.75 ± 1.28
Crude protein	22.46 ± 1.24
Intramuscular fat (ethereal extract)	0.62 ± 0.46
Ash	1.12 ± 0.05
Carbohydrates	0.34 ± 0.70

Tab. 4: Physical properties of various muscles of the beaver (mean value from 2 hind legs of one beaver)

	M. gastrocnemius	M. tibialis cranialis	M. quadriceps femoris
pH	5.85	5.84	5.82
Cooking loss in %	20.64	15.19	19.44
L*	28.9	47.0	42.2
a*	17.5	8.5	14.05
b*	9.3	6.35	8.25
Shear force in N/cm^2	50.09	20.60	24.38

and the island Navarino. On Tierra del Fuego, Canadian beavers were farmed until fur production ended in 1946 and the animals were released in the forests. Due to favourable climatic conditions and the absence of large predators, beavers multiplied and colonised 75 % of Tierra del Fuego and the southern island Navarino (SIELFELD and VENEGAS, 1980; LIZARRALDE, 1993; BRIONES et al., 2001). Half a century passed until the impact of the beaver colonisation was studied, financed by the National Funds for the Development of the XIIth Chilean Region. Follow-up studies in 1999 revealed that the average beaver density is approximately 1 lodge per km stream, with approximately 5 animals per lodge. Thus, the number of beavers on both islands is estimated to be approximately 61,000 (SKEWES et al., 2004), and still increasing, with severe consequences for the forest.

Historical aspects on the beaver in Europe

From the Middle Ages onwards, beavers were prized for the secretion of the castor gland (Castoreum) and for their meat. Castoreum was widely used as a drug with presumed relaxing and sedative effect. It contains salicin originating from willow bark (from which the analgetic substance salicylic acid was synthetized the first time; WIESNER and RIBBECK, 1983). In catholic countries, beaver meat gained some importance: it was allowed to consume beaver meat during lent, as catholic theologians considered beavers as “fish”. The rationale (or pretext) was, that this animal was adapted to water and the skin on the beaver´s tail is structured like scales of fish (ANONYMOUS, 2004).

Today, both Castoreum and beaver meat have little or only local importance, but the beaver´s fur is still a valuable product, originating both from hunted and farmed animals.

Scope of this study

This study was conducted to generate data on the muscular topography and meat characteristics of beavers in Chile. Although beaver is unlikely to contribute substantially to meat production in this region, sustainable management will result in catching or hunting beavers, with the usage of their muscle tissue as food as a side-effect.

Material and Methods

A number of 25 beavers caught in Tierra del Fuego, Chile, with total body masses ranging from 6.34 to 22 kg were studied. Carcasses were eviscerated, dehided and dissected to study the muscular topography. Carcass and muscle masses were recorded. The carcasses were subjected to veterinary inspection for detection of macroscopic lesions and alterations, microscopic examination for the presence of *Trichinella* sp., and serological testing for *Francisella tularensis* antibodies (BROWN et al., 1980).

Chemical analyses (moisture, crude protein, intramuscular fat, carbohydrates, ash) were performed according to AOAC methods, see GONZALEZ et al. (2004). For technical reasons, determination of pH, meat colour, cooking loss and shear force and sensory evaluation could be done in the hind leg muscles of one animal only. The ultimate pH value was measured with a testo 230 pH and temperature measuring instrument (Testo, Lenzkirch, Germany). Colour was measured by recording L*a*b* values at the muscle surface after blooming 2 hours at 2 °C with a Phymacom Codec 400 (Phyma, Gaaden, Austria). For determination of cooking loss, the muscles were weighed, stored in open plastic bags and heated in a water bath (72 °C water temperature) until a core temperature of 70 °C was reached. After chilling in a water bath, cooking loss was determined by re-weighing the muscles and was calculated as percentage of the mass before heating. For shear force measurement, pieces of about 4 cm length and a cross-section of 1 cm^2 were cut out of the muscles after heating and chilling in the way mentioned above. The pieces were sheared with a Warner-Bratzler equipment attached to an Instron 4411 machine (both Instron Ltd., High Wycombe, Bucks, UK). The blade of the Warner-Bratzler equipment had a rectangular hole (width: 11 mm; height: 15 mm). The maximum shear force of each piece was recorded.

For sensory evaluation, beaver meat (hind leg muscles) was compared with pork after cooking in the way mentioned above as well as after grilling at 200 °C until a core temperature of 75 °C was reached. 6 persons evaluated tenderness, juiciness and taint of the beaver meat by comparison with pork on a 5 point scale.

Additional anatomical studies were conducted at the Institute of Anatomy, Vienna, with 3 deceased specimens of *Castor fiber*.

The study was performed in accordance with national animal welfare and species protection law.

Results

Muscular topography of the beaver

In this study, we focused on the muscles of the limbs, as these, and in particular, the hind limbs, are of relevance as meat source. The M. gluteus superficialis is larger than in domestic mammals, with a broad insertion from the cranial end of the Ala ossis ilii to caudal of the Trochanter major from the Fascia glutea (Fig. 1). The muscle covers the Trochanter major and the hip joint and inserts in the Trochanter tertius. This Trochanter tertius is located in the mid of the Os femoris, which is far more distal as e.g. in horse or rabbit.

The M. gluteus medius and the M. gluteus profundus are relatively small (Fig. 2). M. biceps femoris consists of 2 fully separated units, with a cranial cord-like part and a wide caudal part partly fused with the Fascia lata, and completely fused with the lateral head of the M. gastrocnemius. Both muscles insert with a common strong tendon on the Tuber calcanei. The M. semitendinosus is located caudal of the M. biceps femoris, and shows no peculiarities, while the M. semimembranosus is divided into 2 parts. The M. gracilis is poorly developed, covering only the caudal part of the medial surface of the thigh (Fig. 3).

The Mm. adductores and the M. pectineus are well developed, whereas a M. sartorius could not be found. The strong M. quadriceps femoris constitutes the cranial part of the thigh. The M. gastrocnemius is located at the caudal part of the lower leg, and fused with the M. biceps femoris (see above). The moderately strong M. flexor digitorum superficialis is inserted between the 2 heads of the M. gastrocnemius. The muscles of the lower leg are generally well developed; they end in tendons in the distal third of the Zeugopodium. Among the pelvic muscles, only the M. iliacus is well developed, while the M. psoas major and the M. psoas minor are small and not relevant as meat cuts. The back muscles, especially the M. longissimus are small. The muscles of the tail are strong. The M. sacrococcygeus ventralis and the M. sacrococcygeus lateralis are strong bundles inserting on the sacral vertebrae, while the M. sacrococcygeus dorsalis is constituted from numerous smaller bundles, stretching from craniodorsal to caudoventral. The muscles end in tendons, in height of the beginning of the scaly part of the beaver´s tail (fin tail).

In Canada, only the parts caudal of the last ribs (caudal parts of the rump and the hind limbs) are used for meat production (Fig. 4).

In Chile, the hind limbs are separated in the hip joint, and then the cranial limbs and the longissimus muscles are removed (Fig. 5).

With respect to the shoulder girdle of the beaver, the clavicula is strong and has to be cut when the cranial limbs are separated from the rump. According to the Chilean cutting scheme, the well developed M. pectoralis profundus remains on the rump, but it is also possible to remove it in connection with the cranial limb, which would improve meat yield. The M. deltoideus and the M. triceps brachii are well developed, as are the muscles of the lower arm. They end in tendons in the distal third of the Zeugopodium.

These findings in Canadian beavers dissected in Tierra del Fuego applied also to those in *Castor fiber* specimens studied in Vienna.

Yield of muscle tissue

Carcass yield was determined from 25 beavers caught in Tierra del Fuego. After evisceration and dehiding, the carcasses were dressed according to regional habits, i.e. legs were cut in the carpal and tarsal joints, and the head was separated (Fig. 6). The average carcass yield was 48.07 ± 2.45 %. Tab. 1 contains further information. Meat cuts were obtained as shown in Fig. 5 and their masses and relative amounts are reported in Tab. 2. The longissimus and hind legs muscles represent 33.22 % of the carcass mass, or 15.97 % of the body mass.

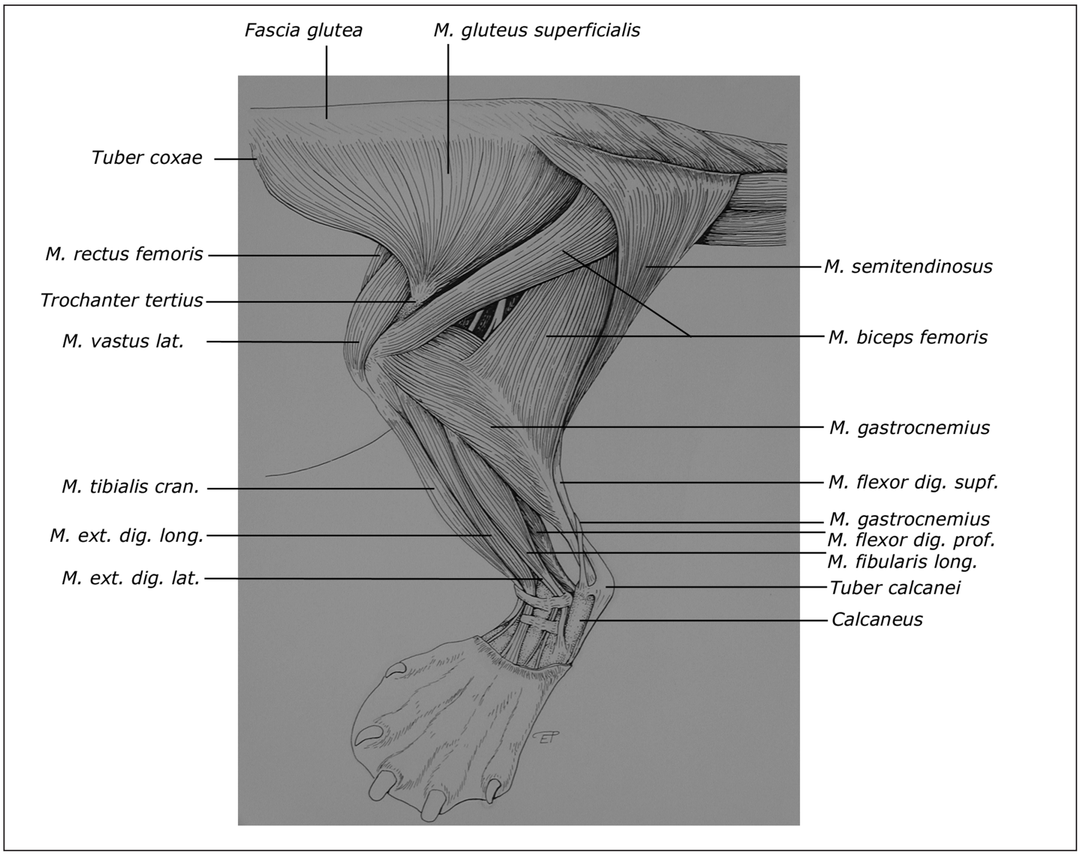

Fig. 1: Topography of the lateral muscles of the hind limb of *Castor fiber*

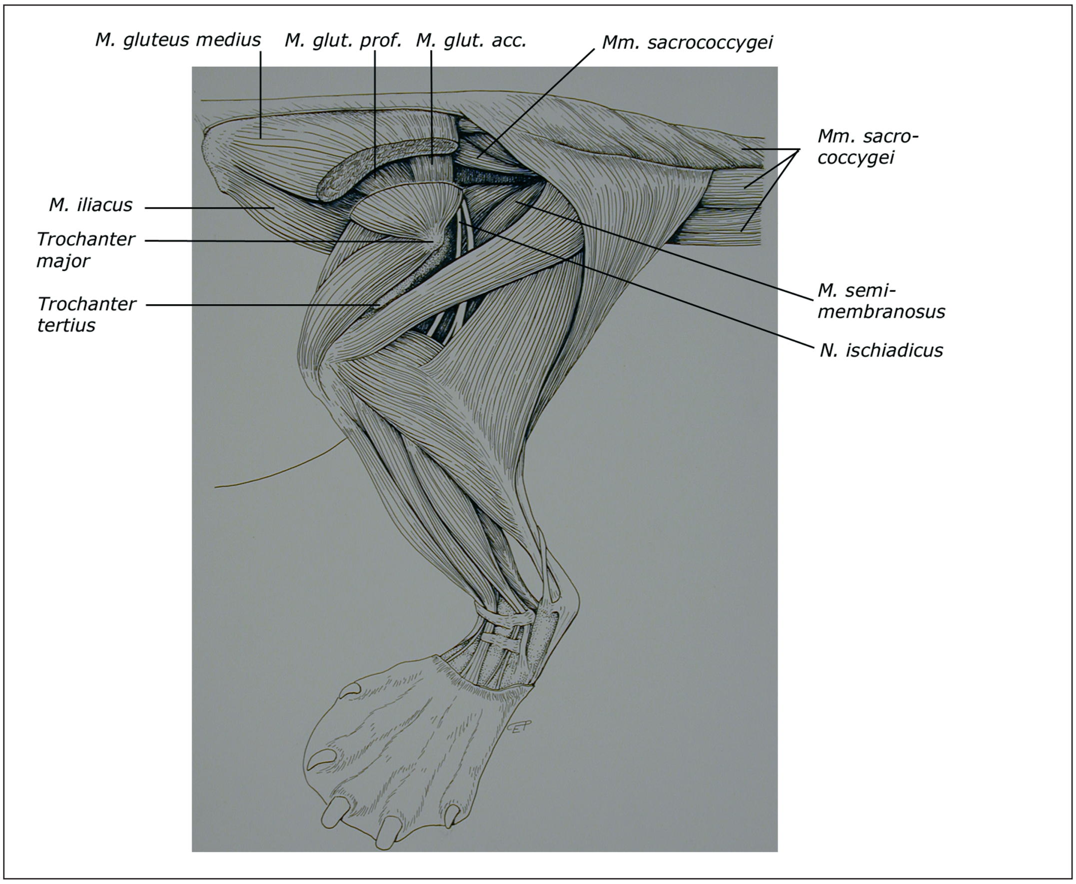

Fig. 2: Topography of the lateral muscles of the hind limb of *Castor fiber*, M. gluteus superficialis removed

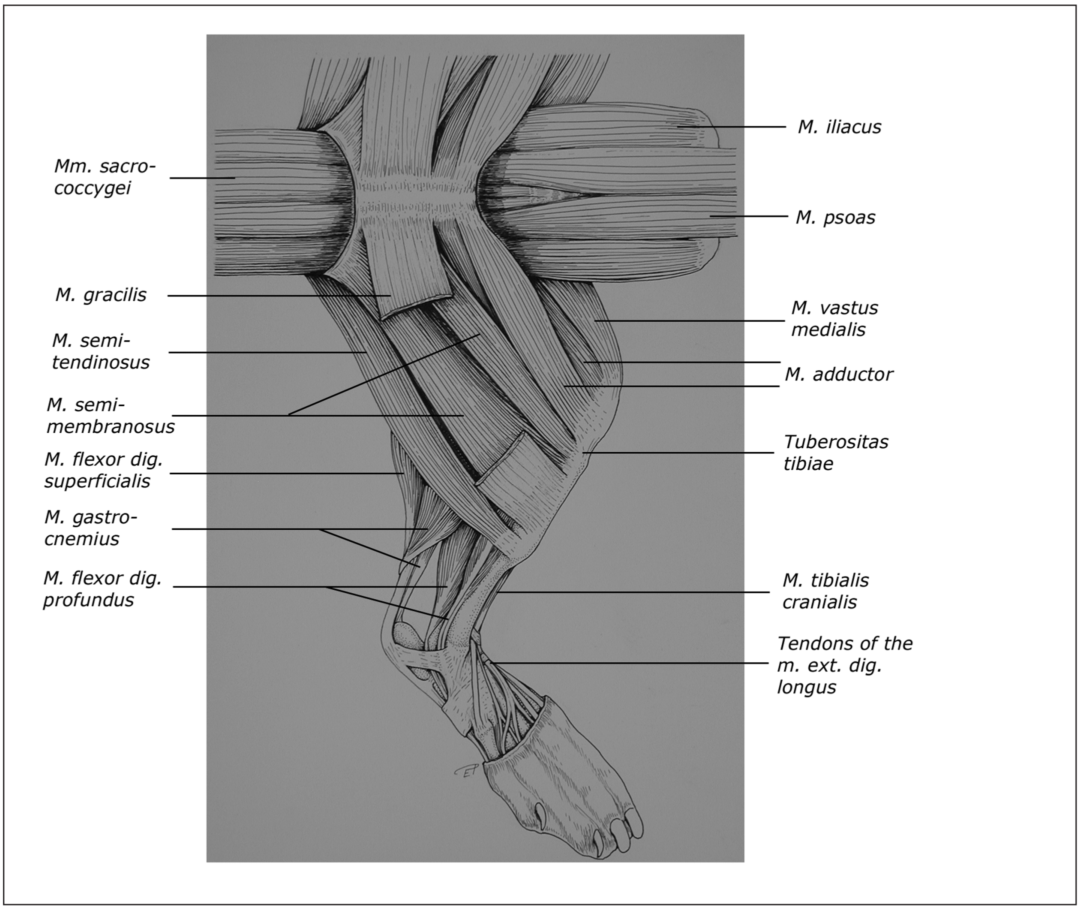

Fig. 3: Topography of the medial muscles of the hind limb of *Castor fiber*, M. gracilis partially removed

Fig 4: Primal cut of beaver, Canadian style (caudal part of the rump, hind limbs and muscular part of the tail)

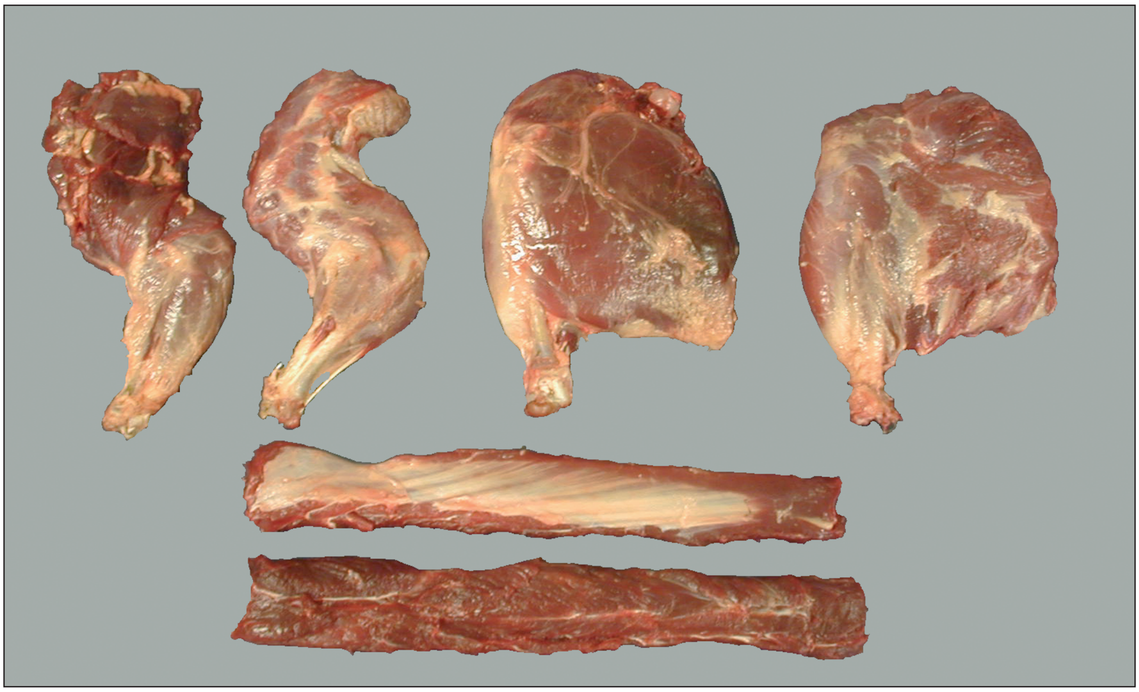

Fig. 5: Primal cuts of beaver, Chilean style (front limbs, hind limbs, and longissimus muscles)

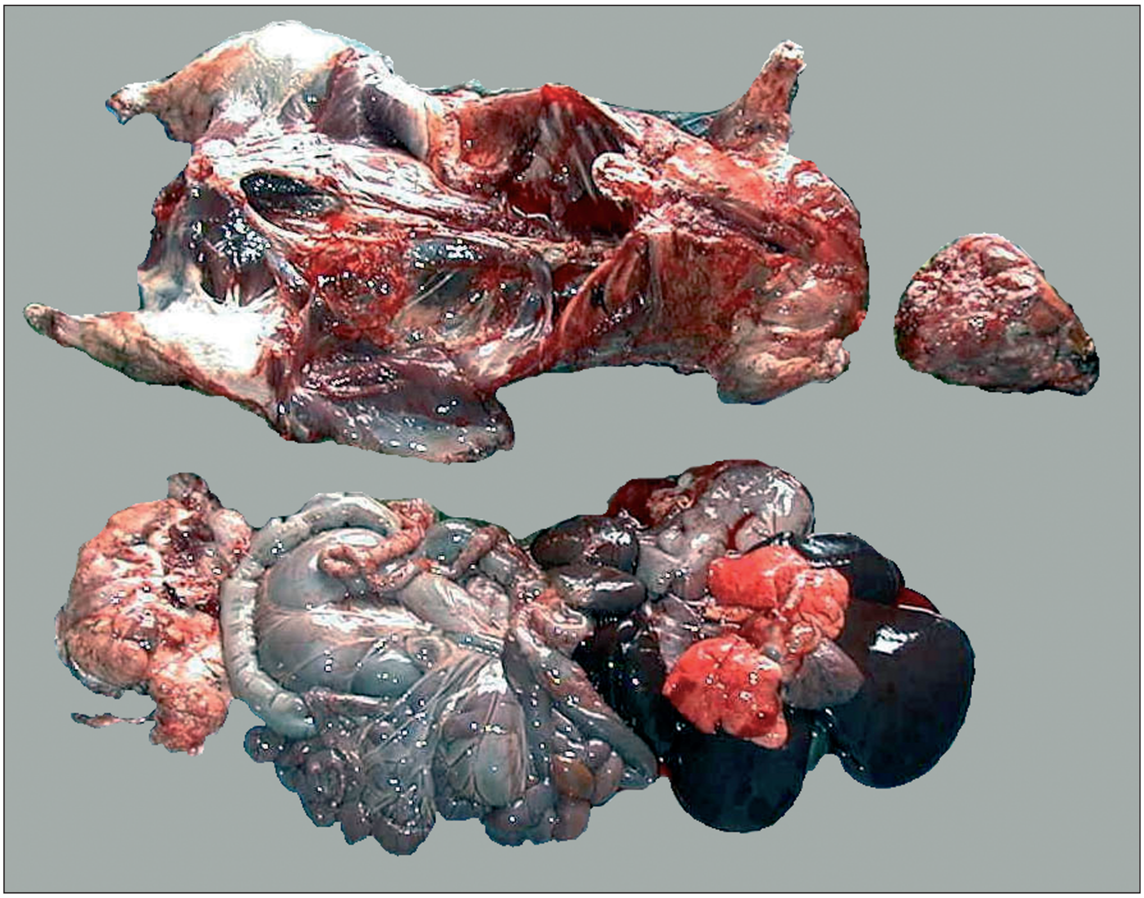

Fig. 6: Beaver carcass dressed in Chilean style, with head separated, and viscera; note the size of the viscera relative to the carcass.

Chemical composition

The composition of muscle tissue (samples from n = 10 animals) is given in Tab. 3.

Sensory and physical properties of the hind leg muscles (M. tibialis cranialis, M. quadriceps femoris, M. gastrocnemius)

In comparison to pork, beaver meat was evaluated as being more tender and having higher taint intensity both in cooked and grilled meat. The difference was more pronounced in grilled meat. Grilled beaver meat was evaluated as being juicier than grilled pork; in cooked meat, differences were negligible. Some testers noted a "slightly fish-like" taint.

The physical properties of 3 muscles of the hind leg are shown in Tab. 4.

Veterinary meat inspection

Macroscopical examination revealed only alterations related to the mode of catching; *Trichinella* sp. was not detected and all sera tested negative for *Francisella tularensis* antibodies.

Discussion

Anatomy and meat yield

Concerning anatomy, recent studies focus on inner organs (gut: BISAILLON and LARIVIERE, 1976; stomach: BISAILLON and BHERER, 1977; heart: BISAILLON, 1982), but not on the muscular system.

Body mass and mass of carcass are lower and carcass yield is at about the same level as described by KORZENIOWSKI et al. (2001), who reported an average body mass of live beavers of 17.5 kg and a carcass mass of 8.050 kg, which means a carcass yield of 46 %. They dissected the carcasses into 4 parts. Thigh formed the largest proportion of carcass (32.7 % of its weight), followed by the lower and upper part of the central area (28.4 and 23.9 % respectively) and shoulder (14.3 %).

Concerning the contribution of the various parts to the carcass, it is notable, that there are differences between the Canadian and the Chilean cutting style, as mentioned above. In the Chilean style, e.g. the front legs are also used. In contrast, separation of the hind limbs in the hip joint results in a loss of muscle tissue (e.g. M. gluteus medius and M. gluteus profundus). According to KORZENIOWSKI et al. (2001), beaver's carcass contains 73 % meat, 21 % bones and 6 % fat. In addition to carcass and valuable fur, beavers are prized for their tail, which is composed of two parts: tail proper which contains 75.7 % meat, and fin tail which contains no meat but is rich in fatty tissue forming 44.6 % of its mass.

Meat quality characteristics
Chemical composition

Concerning the results of the chemical analyses, the composition of beaver meat is similar to that of beef, pork and meat of some game species like roe deer or hare with the exception of fat content, which is lower in beaver meat.

According to SOUCI et al. (2000) the content of water, protein, fat, and minerals are 74.1, 22, 1.9 and 1.23 %, respectively, for beef (muscles only), 74.8, 22.2, 1.9 and 1.2 %, respectively, for pork (hind leg), 75.7, 21.4, 1.25 and 1.01 %, respectively, for venison (roe deer, leg) and 73.3, 21.6, 3.01 and 0.99 %, respectively, for hare.

Sensory and physical meat traits

Only meat from one beaver could be investigated for these parameters, so the results are a first information and further investigations have to be done.

Veterinary meat inspection and microbiological examination

From the sanitary inspection of the carcasses, no objections were raised against the consumption of the beavers´ meat. However, toxoplasmosis (FORZAN and FRASCA, 2004), cysticercosis (*Echinococcus multilocularis;* JANOVSKY et al., 2002) and leptospirosis (METTLER u. WEILENMANN, 1974) have been detected in beavers, but the latter 2 reports deal with zoo and not free-range animals. *Giardia* sp. were detected in beaver fecal samples in the USA (PACHA et al., 1987), but not in Sweden (ROSELL et al., 2001). Studies suggest that this water-adapted animal generally is not a carrier of human pathogenic enteric bacteria, such as *Campylobacter* and *Salmonella* (ROSELL et al., 2001). In summary, meat of beavers bears the same hazards as the meat of other game species.

Acknowledgements

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Pharmaceutical and nutraceutical management of canine osteoarthritis: Present and future perspectives (Pharmakologische und „ernährungspharmakologische“ Behandlung der Arthrosis deformans des Hundes: gegenwärtige und zukünftige Möglichkeiten) HENROTIN, Y., SANCHEZ, Ch., BALLIGAND, M. (2005): Vet. J. **170**, 113 - 123.

In diesem Übersichtsartikel wird zuerst auf die Pathophysiologie der Arthrosis deformans (AD) eingegangen. Große Bedeutung kommt den Chondrozyten zu, die eine Imbalance zwischen katabolen und anabolen Prozessen herstellen, was zur fortschreitenden Zerstörung der Matrix führt. Die Synovia mediiert Autoimmunprozesse, die ihrerseits zu Zerstörung von Knorpel und Gelenk führen. Schließlich kommt der Sklerosierung des subchondralen Knochens große Bedeutung zu.

Bei der pharmakologischen Behandlung werden die nichtsteroidalen Antirheumatika genannt, wobei in Zukunft den selektiven COX-2 Hemmern vermehrt Bedeutung zukommen wird. Schließlich wird auf eine neue, interessante Gruppe entzündungshemmender Stoffe eingegangen, die sowohl die Cyklooxygenase als auch die Lipoxygenase hemmen (Vertreter: Licofelone, Tepoxalin).

Das Anthrachinon Diacerhein ist als Prodrug von Rhein anzusehen. Dieser aktive Metabolit findet sich im Plasma und in der Synovialflüssigkeit. Rhein hemmt vermutlich die Bildung von Matrixmetalloproteasen und stimuliert die Bildung von Aggrecan durch die Chondrozyten. Dieser positive Effekt wird über Stimulation der Genexpression von Transforming Growth Factor (TGF)-β1 und TGF-β2 erklärt sowie über Hemmung der IL-1β Sekretion.

Die Kortikosteroide haben nach wie vor ihren festen Platz in der Behandlung der AD.

Abschließend wird die intraartikuläre sowie intravenöse Injektion von Hyaluronsäure bzw. ihres Natriumsalzes behandelt.

Bei der „ernährungspharmakologischen“ Behandlung wird darauf hingewiesen, daß es sich um definierte Substanzen handelt, die keineswegs mit Futterergänzungsmitteln u.ä. zu verwechseln sind.

Als erstes werden Glukosaminsulfat und Chondroitinsulfat besprochen. Nach Abhandlung der möglichen Wirkungsmechanismen wird darauf hingewiesen, daß positive Effekte durch eine Vielzahl anekdotischer Berichte "belegt" sind, es dazu aber praktisch keine klinischen Studien gibt.

Dem Natrium- und dem Kalziumsalz des Pentosanpolysulfates werden eine Vielzahl von positiven Effekten auf die katabole und anabole Aktivität der Chondrozyten zugeschrieben. In einer Plazebo-kontrollierten Studie wurde das Kalziumsalz nach der Operation des kranialen Kreuzbandes über einen längeren Zeitraum verabreicht. Nach einjähriger Beobachtung unterschied sich die Behandlungs- nicht von der Plazebogruppe was Funktion des Gelenkes und radiologisch gesichertes Fortschreiten der AD betraf.

Ein Gemisch (1:2) aus Avocado und Sojabohne (nicht verseifbare Anteile) soll beim Menschen wirksam sein (Steigerung der TGF-β1 Produktion, Hemmung der Matrixmetalloproteasen Produktion). Beim Hund fehlt jede Erfahrung.

Schließlich wird noch ein Proteinkonzentrat aus der Milch hyperimmunisierter Kühe, eine Diät mit niedrigem omega-6/omega-3 Fettsäureverhältnis und ein Miesmuschel (Green Lipped-) pulver erwähnt.

Wichtigste Intervention bei der AD bleibt aber nach wie vor die Gabe nichtsteroidaler Antirheumatika.

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