THESES OF DOCTORAL (PhD) DISSERTATION

UNIVERSITY OF KAPOSVÁR

FACULTY OF ANIMAL SCIENCE

Department of Poultry and Companion Breeding

Head of the Doctoral School:

DR. PÉTER HORN

Ordinary Member of the Hungarian Academy of Sciences

Supervisor:

DR. LÁSZLÓ SUGÁR

CSc. of veterinary science

OCCURRENCE OF *ELAPHOSTRONGYLUS CERVI* IN THE CENTRAL NERVOUS SYSTEM AND MUSCULATURE OF RED DEER UNDER DIFFERENT ECOLOGICAL CONDITIONS IN THE PANNONIAN REGION

Author:

SZILVIA KOVÁCS

KAPOSVÁR

2010

1. ANTECEDENTS AND AIMS OF THE RESEARCH

Due to the worm specimens found in the thoracic musculature of a Scottish red deer (*Cervus elaphus* L.) became known the so-called tissue worm *Elaphostrongylus cervi* (CAMERON 1931), as a member of the Protostrongylidae family (ANDERSON, 1978). Adult nematodes are usually settled in the connective tissue between the fascia of the thoracic, subscapular and back, occasionally other sceletal muscles, however immature worms can be found in the subdural space of the cranial cavity (central nervous system=CNS) according to RONEUS AND NORDKVIST (1962), KUTZER AND PROSL (1975), SUGÁR AND KÁVAI (1977). *E. cervi* seems to be common on any areas where red deer is abundant, like in Austria (KUTZER AND PROSL, 1975), the former Czechoslovakia (DYKOVA, 1969), Hungary (SUGÁR AND KÁVAI, 1977), Kazakhstan (PRYADKO ET AL., 1963).

In the course of the experiments, done with its close relative, *Elaphostrongylus rangiferi* living in reindeer, it came to light that the worms occurring in the CNS will migrate to the sceletal musculature alongside nerves (HEMMINGSEN ET AL., 1993). The similar routine migration of *E. cervi* worms in red deer was demnonstrated by HANDELAND ET AL. (2000).

In the course of my study I examined the circumstances of *E. cervi* occurrence in red deer living in various ecological conditions. I was searching to answer the following questions:

1. How frequently do this nematode species occur in the CNS of red deer in the different Pannonian populations?
2. May *E. cervi* specimen be present in the vertebral canal?
3. Is there any relationship between the prevalence/intensity and the age of animals or the date (period) of examination respectively?
4. Is there any relationship between the nutritional status and the infection?

2. MATERIALS AND METHODS

Red deer samples were collected between 2005-2009 (during four hunting seasons) especially on hunting grounds in Baranya, Somogy and Zala counties and in the Centrum of Game Management (Bőszénfa), University of Kaposvár. Beside them I had the opportunity to examine red deer occasionally in Kab-hill, the King Mathias Game Park, the Gemenc Forest and the Small-Balaton hunting units (*Table 1.*).

Table 1. **The distribution of examinations according to study areas, seasons and the location of parasitic occurrence in deer**

<table>
<tr><th rowspan="2">Study area</th><th rowspan="2">Season</th><th colspan="4">Number examined (n)</th></tr>
<tr><th>Cranial cavity</th><th>Vertebra</th><th>Musculature</th><th>Faeces</th></tr>
<tr><td rowspan="4">1. Somogy</td><td>2005/06</td><td>26</td><td></td><td rowspan="9">17</td><td rowspan="4">94</td></tr>
<tr><td>2006/07</td><td>103</td><td></td></tr>
<tr><td>2007/08</td><td>50</td><td>12</td></tr>
<tr><td>2008/09</td><td>60</td><td>9</td></tr>
<tr><td rowspan="2">2. Baranya</td><td>2006/07</td><td>19</td><td></td><td></td></tr>
<tr><td>2007/08</td><td>19</td><td>1</td><td></td></tr>
<tr><td rowspan="2">3. Zala</td><td>2006/07</td><td>26</td><td></td><td></td></tr>
<tr><td>2007/08</td><td>21</td><td>3</td><td></td></tr>
<tr><td>4. Tolna</td><td>2005/06</td><td>31</td><td></td><td></td></tr>
<tr><td>5. Bőszénfa</td><td>2006/07
2007/08
2008/09</td><td></td><td></td><td>15</td><td>340</td></tr>
<tr><td>6. Other</td><td>2005-2009</td><td>15</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Total</td><td>370</td><td>25</td><td>32</td><td>434</td></tr>
</table>

The age of deer was estimated on the basis of the dentition (teething, changing of teeths, tooth wear).

2.1. Examination of the cranial cavity

In the course of the examination period of four years the cranial cavity of 238 calves, 44 yearling hinds and 88 hinds was examined; and worms and pathologic alterations were looked for. The head of hunted animals were opened by a mid-sagittal cutting and the cerebrum was removed. Both its surface and the cavity were thoroughly looked through by binocular eye-glasses 1.8 zoom. The worms found were collected; and portions of cerebrum or of the meninx with pathologic alteration were fixed in 8% buffered formaldehyde-solution for later histology. The worms stored in 70% ethyl-alcohol were examined with Olympos strereo-microscope, their sex was determined and length was measured in mm-s.

2.2. Examination of the vertebral canal

Out of 25 vertebra (cervical, thoracic, lumbar portions) collected in the two winter seasons and examined altogether 19 samples were valuable.

After that the meat was removed in the venison processing plant, the vertebral canal was opened with a chisel on both sides at the vertebral arch; and the spinal cord was removed in length of 1-2 vertebrae. The removed parts of the vertebral canal and spinal cord were examined with magnifying glass, and then they were placed in physiologic NaCl solution. The position of the found worms was recorded in digital photos.

2.3. Examination of carcass

In the course of processing venison in the plants Öreglak and Bőszénfa 32 carcasses were examined for isolation of adult *E. cervi* worms.

The main predilection places (scapula, thoracic muscle fascia) were examined and documented in photos. The found worms were collected for later analyses; samples were taken from the parts adjacent to worms found, which were fixed in 8% buffered formaldehyde-solution for later histological examination.

2.4. Examination of faeces

The larval content can be examined and counted during a sedimentation process of the faecal samples. Altogether 434 faecal samples were analysed to isolate larvae in the hunting season. Out of them altogether 340 samples were collected from deer kept on the farm and 94 from wild deer. The farm samples were collected in the deer-gardens, while for 21 yearling hinds the samples were taken from rectum. The wild deer were hunted in the Zselic, the samples were collected post mortem from the rectum. The cooled samples were analysed with Baerman sedimentation method and examined with light microscope.

2.5. Examination of body measurements, nutritional status and age of deer

During four hunting seasons I examined the body size and nutritional status (kidney-fat index) of hunted wild calves and females only such as the jaw and *metacarpus* length and nutritional status of 239 red deer in Somogy county during the 2005/06, 2006/7, 2007/08 and 2008/09 seasons, 31 red deer in Tolna county in the 2005/06 season, 38 red deer in Baranya county in the 2006/07 and 2007/08 seasons, 47 red deer in Zala county in the 2006/07 and 2007/08 seasons. Farm red deer (n=15) kept in Bőszénfa were examined in late May 2007 in the course of a diagnostic slaughter.

2.6. Statistical analysis of the data

In order to determine the degree of infection usual parasitological statistical indicators were used: *prevalence, intensity, abundance*. The collected data were recorded and systematized with *Ms Excel*. For statistics the software *Quantitative parasitology 3.0* and *SPSS 11.5* were used. In the comparison of four hunting seasons and different counties, significant difference was looked for between seasons or areas at 5% significance level ($p \leq 0.05$). To compare the prevalence of two or more samples *Chi-square test* and *Fisher exact test* were used. The correlation between the nutritional status and parasite infection of calves was analysed with *Pearson correlation analysis*.

3. RESULTS AND DISCUSSION

3.1. Results of the cranial cavity examinations

Analysis of calves

As regard to the total figures of the four hunting seasons *E. cervi* worms were found in the cranial cavity in 42.9% of the examined calves (n=238).

For the calf samples collected in the hunting season of year 2005/06 the prevalence of *E. cervi* was 22.5% and the average intensity is 1.14. These figures for January were 16.7% and 1.33 and for February 36.4% and 1, respectively.

In the hunting season 2006/07 based on the examination of 80 calves the prevalence of worms was found 51.25% with an average intensity of 2.64. The frequency figures 57.9% in November, 66.7% in December and 61.5% in January were all higher than 16.7% observed in the previous year on a bigger sample. The prevalence was 30.4% in February. In May one-one worm was found in four out of the seven hunted deer in Szántód (57.1% prevalence).

In the hunting season 2007/08 75 calves were examined. *E. cervi* worm was found in seven out of the nine animals examined in October, with a prevalence of 77.8%. The highest number of worm was 12 in a calf from Baranya county; the worm evidence was well shown by large thickenings on the *dura mater*. The frequency in November (33.3%) does not show a realistic picture due to the small sample size (n=6). The examination in May led to negative result despite the double sized sample. In the Small-Balaton area one-one worm was found in two calves in June and in one calf in August.

In the hunting season 2008/09 the cranial cavity of 50 calves from Somogy county was examined between October and February. The high prevalence figures found in January and February (66.7%, 71.4%, respectively) would have been lower in samples with similar size than in the previous years; as in this season of the year a part of the worms moves to the fasciae of the skeletal muscles.

Results of the yearling hinds examinations

As total figures of the four hunting seasons (period between 2005 and 2009) the data in case of yearling hinds (n=44) were much lower than in case of calves: prevalence 6.8%, intensity 1.3.

There were no worms found in the cranial cavity of 8 yearling hinds examined in the hunting season 2005/06. In the season 2006/07, two *E. cervi* worms were recorded in only one out of 21 yearling hinds examined (prevalence 4.76%). In the season 2007/08, one-one *E. cervi* worm was found in the cranial cavity of two out of 10 yearling hinds examined (prevalence 20%). There were no worms recorded in the cranial cavity of 5 yearling hinds examined in the hunting season 2008/09.

Results of hinds examinations

The average prevalence of hinds (n=88) was 4.5% and the average intensity was 1.5 during the four hunting seasons.

No worms or pathologic changes were found in the 20 hinds examined in the hunting season 2005/06. Two-two *E. cervi* worms were found in two hinds and one in one hind out of 49 animals in the season 2006/07 (prevalence 6.12%). In the 2007/08 hunting season the examination of cranial cavity of 11 hinds led to negative results. In the season 2008/09, one *E. cervi* worm was found on the dura mater of a 2½ year old hind (prevalence 16.7%).

Length of worms found

The body length of the *E. cervi* worms found in cranial cavity varied between 2.6 and 6.7 cm's. The males' length was between 2.6 and 5.6 cm's, while the females' length between 4.1 and 6.7 cm's.

Statistical evaluation of the data

Table 2 shows the results observed in the examinations of four years. Calves outstand among the data, which are the most sensitive to infection. Among 238 examined calves, 102 animals had *E. cervi* worm infection in their cranial cavity. The worm count varied from 1 to 12. DEMIASZKIEWICZ (1987) found only one worm, ERIKSEN ET AL. (1989) two worms, while KUTZER AND PROSL (1975) found 18 *E. cervi* worms as the maximum in a calf. Even more, 30 worms were recorded in a calf from Gemenc in February 1979 (SUGÁR NOT PUBL).

Table 2. **Detailed statistics of the *E. cervi* occurrence data in red deer examined between 2005-2009**

∑ number examined	**370**		
Age-group	***Calf***	***Yearling hind***	***Hind***
Number examined	**238**	**44**	**88**
Number of infected	102	3	4
Prevalence (%)	42,9	6,8	4,5
Mean intensity	2,26	1,33	1,5
Median intensity	1	1	1,5
Discrepancy	0,749	0,922	0,951
Mean crowding	4,38	1,5	1,67
∑ number of worms	242	4	6
Min-max. number of worms	1-12	1-2	1-2

Significant difference was found in only one case: the *E. cervi* prevalence figures of the calves from Somogy county differed significantly across seasons (p=0.015).

Two-sample *Bootstrap test* was used to test the difference between average intensity data. No significant difference was found either between seasons or counties.

The correlation analysis been used to define the strength of relation between nutritional status and parasite infection of calves did not show significant linear correlation between the kidney-fat-index I. or kidney-fat-index II and *E. cervi* infection (*Table 3*).

Table 3. **Statistical evaluation of the relationship between the nutritional status and *E. cervi* infection**

Variables		*R*	*P*
E. cervi	KFI 1	0,194	0,052
E. cervi	KFI 2	0,033	0,743

VICENTE ET AL. (2007) analysed the correlation between nutritional status and *E. cervi* larval count in Spanish deer populations on large samples. They found correlation only in case of adult stags between status and larval burden. My own results seem to prove this, as well; at least as regards to seasons: larvae were not found in stags with good nutritional status, while moderate or high prevalence and larval count were seen in the fall – winter season, though the examination of the nutritional status of the animals was not always possible.

3.2. Results of the vertebral canal examinations

In the hunting season 2007/08 10 calves' vertebral columns out of 16 were suitable for examination; *E. cervi* was found in four of them. In two out of three calves from Sasrét, worm was found in the cervical section. In one of them four *E. cervi* and two *Setaria cervi* were found, while in case of the other one altogether 11 *E. cervi*. Among three calves from Zala county *E. cervi* was found only in one of them: at the second vertebra two worms, while at the 6th one *E. cervi* worm. In one out of four calves from Lábod two *E. cervi* worms were found subdurally at the first vertebra.

In the hunting season 2008/09 nine calves were examined, mainly from county Somogy. At the cervical section worms were found in case of 3 calves: in one of them *S. cervi*, in the other one 3 *E. cervi* and one *S. cervi*, while in the third one 1 *E. cervi*. (In the second case 1 *S. cervi* was found at the thoracic section.) In the third case 2 *E. cervi* worms were found in the cranial cavity, as well. In case of five calves no worms were found in the vertebral canal; though in three cases 2, 6 and 4 *E. cervi* worms were found in the cranial cavity. At the thoracic section of the vertebral canal worm (*S. cervi*) was found in only one case.

3.3. Results of the carcass examinations

In 2008, in the course of the examination of carcasses in the Venison processing plant of Öreglak *E. cervi* worm was found mostly under the scapular muscles. *E. cervi* was found in case of one animal near to the vertebral column at the 6th and 7th vertebrae under the scapular and thoracic muscles, in another cases at the forearm (3 animals), in the thigh muscles (2), around the lumbar portion (1), totally in seven animals (prevalence 41.2%).

Following the tuberculin diagnostic slaughtering of 15 stags in May 2007 in the processing plant of Bőszénfa worms were found in altogether four cases under the scapular muscles and thoracic muscles (prevalence 26.7%).

The length of whole worms was between 3.2 and 6.4 cm's; 62% of them was male (3.2 to 4.9 cm's) and 38% was female (4.2 to 6.4 cm's). The recorded figures are similar to those of other researchers, thus VALCÁRCEL AND ROMERO (2002) defined the length of males between 2.9 and 4.1 cm's and for females between 3.3 and 5.8 cm's. DEMIASZKIEWICZ (1987) found worms in the connective tissue fasciae of 32 animals with an intensity of 1 to

20. The length of collected worms was between 3.0 and 4.7 cm's (male) and between 4.5 and 6.7 cm's (female), which figures are also close to my findings.

3.4. Results of the faeces examinations

According to my researches the *E. cervi* prevalence figures are high in wild calves as early as from January (64.3% January, 61.1% February, 80% March) with varying larval count (2 to 800 LPG). In hinds moderate (33.3% February) and high (72.7% January, 50% April, 83.3% June) prevalence was found with highly varying larval count (1 to 1800 LPG).

In case of farm calves aged up to half year larvae excretion was not found until November. In springtime, though, the prevalence was relatively high (33.3 to 45.55) and the larval count was also high (min. 1 to 780 LPG). In case of stags the prevalence of larvae was found from 0% through a moderate level (18.8%) up to 100%. The high figures seen (77.8% October, 100% November, 100% March) prove the evidence of an increasing excretion of larvae. The high figures found in case of hinds and yearling hinds between November (76.9%, 63.9%, respectively) and March (90.5%) correspond with the earlier findings of KUTZER AND PROSL (1975), VICENTE ET AL. (2005) and MASON AND MACALLUM (1976). In case of hinds, the minimum larval count was 1, while the maximum count was 850 per sample.

In the seasons of late winter and springtime, the prevalence of wild calves were higher than that of farm calves, similarly to the findings of ENGLISH ET AL. (1985). In case of adult animals, with the exception of a few months, high prevalence ratios were found in both environments in case of hinds and in case of farm stags. Of course the anti-parasitic treatment of the farm deer may have influenced the excretion of larvae.

3.5. Results of the body measurements, nutritional status and age examinations

According to the collected data, the longitudinal growth of the leg *metacarpus* slows down around at age of one and a half year; while it terminates at age of 5 years; while the growth of mandible terminates only at older age around 10 years. It was not possible to examine stags older than one year due to the preparation practice of trophies, therefore the hunted animals were divided into three groups: calf (both sexes), yearling hind (1.5 to 2 years old), and hind (above 2 years).

On the basis of the statistical analysis of the collected data in regard of kidney-fat-indices of deer been hunted in the four hunting seasons it was found that the nutritional status of young hinds is the best, whereas it is somewhat worse in case of hinds of prime age. The poorest nutritional status was found in case of calves according to the index. In county Zala, the best nutritional status was found in case of yearling hinds, while in Somogy in case of young hinds. The kidney-fat-index (KFI) data of red deer stags recorded in May in the venison processing plant were much lower than that of free-range hinds hunted in wintertime. According to the calculated KFI indices, thus, it was found that the calves are in poorer nutritional status, whereas in Somogy county the yearling hinds were in poorer nutritional status than hinds.

4. CONCLUSIONS

On the basis of evaluating the representative sample of red deer it can be stated that *Elaphostrongylus cervi* nematode occurs regularly in the cranial cavity of red deer calves (prevalence=42.9%), moreover in some areas and certain seasons more frequently. The low prevalence in yearlings (6.8%) and adult hinds (4.5%) is showing the effectiveness of the acquired immunity interrupting the migration of young *E. cervi* specimens, what was proved in reindeer in Norway by GAUDERNACK ET AL. (1984) and later in Spanish red deer by VICENTE ET AL. (2007).

The concentration of the worm presence into the winter season is related to the life cycle of *E. cervi* attached to the environmental conditions outside the final host, namely to the activity and availability of intermediate snail hosts. The thickening of this occurrence of worms in the cranial cavity to the October-February period is in harmjony with the experiences of KUTZER AND PROSL (1975). The explanation of it is the following regularity: the young species of the worm develop into adults in the central nervous system (CNS), then they migrate alongside nerves to the trunk musculature to settle. Their presence restricted almost totally to the autumn-winter period in CNS is obviously related to the regular, not intentional snail consumption of deer. However it has to mention that in some cases I found worm specimen(s) in the cranial cavity of the 12-15 month-old animals during the late spring – summer period too.

The migration of *E. cervi* in the CNS of red deer was proved by HANDELAND ET AL. (2000) in Norway with experimantal infections. However examinations extended to the vertebral canal/spinal cord were not completed until now. This study due to investigating naturally infecdted calves has proved this regularity, however *E. cervi* worms were found only in the cervical section (prevalence=31.6%, in 19 calves). The cause of it is preasumably the nature of this migration: most of the worm specimens migrating backward from the cranial cavity leave the canal at the cervical section (namely at the strong *plexus brachialis* trunk) to get to the main settling locations (thoracic, scapular and back musculature).

The worm migration in the host organism do not take place without any permanent trace in most cases. Alterations were often detected on the inner surface of the *dura mater* of cerebrum and sometimes on/in the brain too. In many occasions even when worm was not present. It refers to that adult worm specimens do not remain/settle in the cranial cavity. In adult hinds wart-like growths, tickenings are very often visible on the surface of the soft meninx (*pia mater*). In some cases there were similar formulas on the inner surface of the *dura mater* in the spinal cord of calves.

It is also worth mentioning that beside the prevalent *E. cervi* nematode and other nematode species, namely *Setaria cervi* may occur too int he cranial cavity of red deer. The similar seasonality of this worm species is probably because its presence in the cranial cavity is rare in general (prevalence=1.9%), on the other hand its prevalence was much higher in the vertebral canal of calves during winter, namely equal with that of *E. cervi* in this anatomical location.

In spite of the prevalent worm occurrence in the CNS and the grossly and microscopic alterations there was not any information abour nervous/movement symptoms in the red deer populations investigated. Such symptoms were experienced only exceptionally by others in red deer (BORG, 1953; KUTZER AND PROSL, 1975), in contrast with accidental hosts like sheep and goat (SCANDRETT AND GAJADHAR, 2002; SIRONI ET AL., 2006). The lack of clinical symptoms and the effective acquired immunity induces the conclusion that there is a habitual, well balanced relationship between the red deer (host organism) and *E. cervi*. On the basis of all these I agree with the opinion of PROSL AND KUTZER (1981), HOLLANDS (1985), and HANDELAND ET AL. (2000), that the pathogenicity is low in red deer as the final host.

Local tissue alterations/yellow infiltration, petechias caused by the settled adult worms in the inspected carcasses were negligable from food hygienic point of view.

Antiparasitics used on Bőszénfa deer farm seem to be effective against this nematode because L1 larva burden in the faeces samples decreased markedly posttreatment. But after the cessation of the effect-duration (1-6 weeks [KASSAI, 2003]) the larva shedding became more intensive, especially in the winter period. The intensity of larvae was higher in wild calves than in farmed ones. Faeces samples of farm calves, examined almost weekly intervals, were mainly free of larvae. Its possible explanation is that calves born in May will consume plants (with snails) in larger amount just by the end of July and about 3-6 months is needed for the egg production of the worms (HANDELAND ET AL. MTSAI, 2000). The prevalence and intensity of larva shedding was fluctuating in the faeces of wild and farm deer equally over one year of age. However I did not find so much elevated values such as KUTZER AND PROSL (1975).

The use of antiparasitics (eg. ivermectin in salt lick) for wild deer is not common in Hungary. The main reason of it is of financial. Othervise the effect-duration of the antiparasitics may extend up to 6 weeks posttreatment (as above) and because the annual home range of red deer is large, the suitability of venison for human consumption is rather questionable. Further disadvantage of the application is the harmful effect onto the pasture biocenosis (toxicity for the dung flies and beetles [RIDSDILL-SMITH, 1988; FINCHER, 1992; KRÜGER AND SCHOLTZ, 1995]). In regard of the above circumstances the use of some pharmaceuticals has to be considered and in the case of *E. cervi* is needless.

Concerning the conclusions of the study I can forward some practical proposals for game management especially for managers of intensive game keeping, deer farmers in regard of the effective prevention and treatment. The succesful protection would improve the effectivity/profitability of the quality venison production.

Thinking of the future research activity in this theme the prevalence of *E. cervi* larvae in the potential intermediate host (snails) together with the influencing ecological conditions are worth mentioning.

5. NEW SCIENTIFIC RESULTS

1. It can be ascertained (?stateed?) that *Elaphostrongylus cervi* has an overall distribution int he examined Pannonian red deer populations, what serves as an indirect proof of the regular, non intentionall snail consumption (by deer).
2. The migration int he subdural spaces of the CNS is a characteristic of the young *E. cervi* specimens, what is proved by the high prevalence on the one side and the frequent occurrence of the grossly and microscopic (pathohistologic) alterations int he worm free calves on the other.
3. The seasonal and host age-dependent dynamics of the *E. cervi* presence in the CNS is indicating the period of the calves regular infections (summer months). As a result of it, the worms settled in the musculature became sexually mature after the six month of age according to the larva-isolation investigations.
4. The low prevalence of *E. cervi* in deer older than one year of age is suggests that worms do not settle in the CNS as well as it is the indirect proof of the formation (development?) of the effective acquired immunity against migrating young *E. cervi* specimens.
5. The nutritional status of calves was not influenced by the *E. cervi* infection.
6. According to the vertebral canal examinations of *Setaria cervi* nematode are also frequently migrating int he CNS of red deer calves, without clinical symptoms similarly to the *E. cervi* infection.

PUBLICATIONS ON THE SUBJECT OF THE DISSERTATION

Scientific papers in full text in Hungarian:

1. SUGÁR L. – **KOVÁCS SZ**. – KOVÁCS A.: Az *Elaphostrongylus cervi* és a *Setaria cervi* szubdurális előfordulása dunántúli gímszarvasokban, *XLVIII. Georgikon Napok*, Keszthely, 2006. szeptember 21-22., CD kiadvány.
2. SUGÁR L. – ÁCS Z. – **KOVÁCS SZ**. – KOVÁCS A.: Szarvasok, paraziták és más apróságok a legelőn – egy soktényezős, változatos biocönózis. *Gyepgazdálkodási közlemények*, 2006/4. 33-37. p.
3. SUGÁR L. – **KOVÁCS SZ**. – VARGA GY. – BARNA R.: Zselicségi gímszarvasok kondíciójának, testnagyságának és parazitáinak vizsgálata a 2006/07 vadászidényben. *Acta Agraria Kaposváriensis*, 2007, Vol. 11. No.2., 27-33. ISSN 1418-1789.
4. **KOVÁCS SZ**. – SUGÁR L.: Dunántúli gímszarvasok ideg- és izomrendszerében előforduló fonálféregfajok vizsgálata. *XIV. Ifjúsági Tudományos Fórum*, 2008. április 3., Keszthely, CD kiadvány, ISBN 978-963-9369-24-9.
5. **KOVÁCS SZ.** – SUGÁR L.: Három tüdőféregfaj lárváinak előfordulása gímszarvasok hullatékában. *Gyepgazdálkodási közlemények*, 2010 (megjelenésre elfogadva).

Scientific papers in full text in foreign language

1. SUGÁR, L. – **KOVÁCS, SZ.**: Host age, sex related and seasonal dynamics of *Elaphostrongylus cervi* larvae in fenced and free living red deer. *Acta Agraria Kaposváriensis*, 2010 (megjelenésre elfogadva).

Abstracts in conference proceedings in Hungarian

1. SUGÁR L. – **KOVÁCS SZ**.: *Elaphostrongylus cervi* és *Setaria cervi* előfordulása gímszarvasok koponyaüregében a 2006. november-

decemberi időszakban. *MTA Akadémiai beszámolók, Parazitológia, halkórtan*, 2007. 33: 14.

2. SUGÁR L. – **KOVÁCS SZ**. – GLÁVITS R.: Vándorló fonálférgek jelenléte és elhelyezkedése gímszarvasok gerinccsatornájában. *MTA Akadémiai beszámolók, Parazitológia, halkórtan*, 2007. 34: 20.
3. **KOVÁCS SZ.** – SUGÁR L. – GLÁVITS R.: Fonálférgek (*Elaphostrongylus cervi* és *Setaria cervi)* gyakori jelenléte gímszarvasok koponyaüregében. *MTA Akadémiai beszámolók, Parazitológia, halkórtan*, 2007. 34: 18.
4. SUGÁR L. – **KOVÁCS SZ**. – GLÁVITS R.: Nagy gyakoriságú *Elaphostrongylus cervi* jelenlét dél-dunántúli gímszarvasok koponyaüregében. *Kotlán Sándor tudományos emlékülés*, 2007. november 20., Budapest.
5. SUGÁR L. – **KOVÁCS SZ.** – GLÁVITS R.: Fonálférgek gyakori jelenléte gímszarvasok koponyaüregében. *Erdészeti Tudományos Konferencia*, Sopron, 2007. dec. 11.

Abstracts in conference proceedings in foreign language

1. SUGÁR, L. – **KOVÁCS, SZ.** – KOVÁCS, A.: Subdural occurrence of *Elaphostrongylus cervi* and *Setaria cervi* in red deer of West Hungary. In: Advances in Deer Biology, Proc. of the *6th International Deer Biology Congress*, Prague, 7-11 August 2006. (Bartos, L. – Dusek, A. – Kotrba, R. – Bartosová-Víchocá, J. ed.): 73. p.
2. SUGÁR, L. – **KOVÁCS, SZ.** – VARGA, GY. – BARNA, R.: Body size, condition and health status in a red deer population of Somogy county, Hungary. *International Union of Game Biologists XXVIII Congress*, 13-18. Aug. 2007. Uppsala, Sweden, 337. p.
3. SUGÁR, L. – **KOVÁCS, SZ.**: High prevalence of *Elaphostrongylus cervi* in red deer in SW-Hungary. *International Union of Game Biologists XXVIII Congress*, 13-18. Aug. 2007. Uppsala, Sweden, 338. p.

4. SUGÁR, L. – **KOVÁCS, SZ.** – ÁCS, Z.: Certain parasites and other invertebrates on the deer pasture: a unique biocenosis. *1st International Genus Cervus Conference*, Italy, Fiera di Primiero, Sep. 14-17. 2007.

Oral presentation:

1. **KOVÁCS SZ.**: Az *Elaphostrongylus cervi* és a *Setaria cervi* szubdurális előfordulása dunántúli gímszarvasokban, *XLVIII. Georgikon Napok*, Keszthely, 2006. szeptember 21-22.
2. **KOVÁCS SZ.** – Sugár L. – Glávits R.: Fonálférgek (*Elaphostrongylus cervi* és *Setaria cervi*) gyakori jelenléte gímszarvasok koponyaüregében. *MTA Akadémiai beszámolók, Parazitológia, halkórtan*, 2007. 34: 18.
3. **KOVÁCS SZ**. – Sugár L.: Dunántúli gímszarvasok ideg- és izomrendszerében előforduló fonálféregfajok vizsgálata. *XIV. Ifjúsági Tudományos Fórum*, 2008. április 3., Keszthely, CD kiadvány, ISBN 978-963-9369-24-9.
4. MAJOROS G. – SUGÁR L. – **KOVÁCS SZ**.: Csiga-köztigazdás fonálférgekkel való fertőződés lehetőségei a szarvaslegelőn. „*II. Vad- és Legelőgazdálkodás időszerű kérdései" nemzetközi tudományos tanácskozás*, 2009. június 12., Bőszénfa.
5. SUGÁR L. – **KOVÁCS SZ**.: Kerti és vadon élő gímszarvasok *Elaphostrongylus cervi* lárvaürítésének életkor-, ivar- és szezonfüggő dinamikájának statisztikai értékelése. *VIII. Alkalmazott Informatika Konferencia*, 2010. január 22., Kaposvári Egyetem.