Acta Veterinaria (Beograd), Vol. 61, No. 5-6, 489-503, 2011.

DOI: 10.2298/AVB1106489P UDK 612.41.444:599.735.5/731.1

CONCENTRATIONS OF THYROID HORMONES IN VARIOUS AGE CATEGORIES OF RUMINANTS AND SWINE

PAULÍKOVÁ IVETA, SEIDEL H, NAGY O, TÓTHOVÁ CSILLA and KOVÁČ G

University of Veterinary Medicine and Pharmacy, Košice, Slovakia

(Received 21st March 2011)

The goal of the study was to map the blood serum concentrations of thyroid hormones in various age categories in cattle, small ruminants, and swine. Blood serum concentrations of TSH, T_4, and T_3 were analysed in randomly selected healthy animals of various species and age. Age-dependent changes of thyroid hormones were studied in 7 clinically healthy calves during the first 6 months of life. The observation started at the age of one month (body weight 45 – 51 kg). A similar study was done in 9 sucking piglets since birth to 9 weeks of age (weaning at 35 days). Blood samples were taken every week. In calves, heifers, and dairy cows we recorded significant differences in T_4 and T_3 values with the highest levels in heifers ($p<0.05$). The hormones mean concentrations in sheep, goats, and swine corresponded to data reported by other researchers. Within age dependent studies, mean concentrations of TSH showed no significant changes, however, most of the samples showed concentrations below the detection limit of the assay. In the third month close to weaning we found significantly lower serum T_4 concentrations ($p<0.05$), compared with the initial value. Similar, but however insignificant decrease was observed for T_3 concentrations. In the piglets, both T_4 and T_3 concentrations showed a significant ($p<0.001$) decrease during the study with the highest mean concentrations of T_3 and T_4 in the youngest piglets. After weaning, both in calves and piglets concentrations of the hormones slightly increased.

Key words: cattle, goats, sheep, swine, thyroid hormones

INTRODUCTION

Monitoring of iodine status in the human population is inevitable for establishing of national IDD (iodine deficiency disorders) national control programmes. These consist of three major parts, including analyses of TSH and thyroid hormones in the blood serum. Similarly, plasma thyroxin levels (T_4) are also used for iodine status assessment in cattle (Hemingway *et al.*, 2001).

Concentrations of thyroidal hormones in the blood serum (plasma) are not routinely used as indices of iodine status and thyroid function because of labour

input (sample collection and processing, laboratory analyses). However, it should be kept in mind that the final objective of correction of iodine deficiency is not only to increase the access of the population to iodized salt and to normalize the urinary iodine concentration; but the goal is mostly to normalize thyroid function (Delange, 2002).

Increased serum TSH levels, except extreme cases, indicate an insufficiency in the saturation of T_3 receptors in the brain, regardless the level of serum thyroid hormones. Therefore, elevated serum TSH indicates potential risk of iodine deficiency on brain development in newborns (Delange, 1998).

Serum T_4 and T_3 are less specific indicators of iodine deficiency because they are modified usually only in conditions of at least moderate iodine deficiency (WHO, UNICEF and ICCIDD, 2001). Moreover, these levels are largely influenced by age and sex (Delange, 2000). It is known that age-related changes in metabolism of T_3 and T_4 may affect the activity of thyroid hormones during development. During the critical period of brain maturation in mammals, T_3 metabolism reaches the highest levels (Naidoo and Timiras, 1979). On the other hand, ageing reduces conversion T_4 to T_3 in the liver and brain (Margarity *et al.*, 1985). These alterations in thyroid metabolism may be responsible for sub-optimum thyroid status during ageing (Latham and Tseng, 1985).

In moderate and severe iodine deficiency, serum T_4 is low but T_3 is variable, occasionally high due to preferential T_3 secretion by the thyroid. Elevated serum T_3 in spite of low serum T_4 is considered as a protective mechanism to most parts of the body, except the brain, where T_3 is produced locally and not derived from the circulating T_3 (Silva *et al.*, 1978). A biochemical picture associating elevated serum TSH in spite of normal serum T_4 and T_3 is called subclinical hypothyroidism while overt hypothyroidism associates elevated TSH and low T_4 with variable levels of T_3.

Evaluation of thyroid hormones in animals is problematic. Blood concentrations of thyroid hormones are extremely variable. Moreover, it is quite difficult to compare sporadic data from various authors because of different conditions and analytical methods (Todini, 2007).

Regarding the aforementioned, this study was aimed at the determination of TSH, T_4, and T_3 in the blood serum in various age categories of cattle, small ruminants, and swine. In the second part of our study we investigated age-dependent changes of thyroid hormones in calves and piglets.

MATERIAL AND METHODS

Blood serum concentrations of TSH, T_4 and T_3 were analysed in randomly selected animals of various species and age. Concentrations of TSH were determined in 117 dairy cows, 63 calves, 9 heifers, 14 sheep and goats, and 10 pigs; T_4 concentrations in 117 dairy cows, 63 calves, 6 heifers, 14 sheep and goats, and 10 pigs. Concentrations of T_3 were analyzed in 33 dairy cows, 12 calves, 3 heifers, 8 sheep and goats, and 7 pigs. Randomly selected animals were healthy without any sign of thyroid disorder.

Age-dependent changes of thyroid hormones were studied in 7 clinically healthy calves (3 males, 4 females, low-land black spotted and crossbreds) during the first 6 months of life. The observation started at the age of one month (body weight 45 – 51 kg). The animals were kept loosely and fed whole milk twice a day. Following weaning at the age of 3 months, the calves were moved to free housing in larger groups. Blood sampling was done once a month.

A similar study was done in 9 sucking piglets since birth to 9 weeks of age (weaning at 35 days). Blood samples were taken every week.

Blood samples were collected by puncture of *v. jugularis* in ruminants and *v. cava cranialis* in pigs. The hormones TSH, T_4 a T_3 were determined by ELISA with the use of commercial ELISA kits (Human, Germany) and micro-titrimetric plates. Readings of absorbancies and calculations of the concentrations were done by automatic photometer Opsys MR (Dynex Technologies). The used analytical methods indicate the following reference ranges for humans: TSH 0.3–6.2 $mIU.l^{-1}$; T_4 4.4 – 11.6 $ug.dl^{-1}$; T_3 – 0.69 – 2.02 $ng.ml^{-1}$.

The results are expressed in means (x) and standard deviations (sd). Differences between categories of cattle were compared by unpaired Student's t-test (MS Office Excel 2007). Statistical evaluation of differences in the study of age-dependent changes of thyroid hormones was done by one-way ANOVA analysis with subsequent Dunnet's test comparing all vs. the control.

RESULTS

The results of our investigation are presented in Tables 1 – 7 and Figure 1.

Table1. Concentrations of TSH in the blood serum of various age categories of cattle ($mIU.l^{-1}$)

	Calves	Heifers	Dairy cows
x	0.90	0.83	0.97
sd	2.51	1.21	3.18
min	0.00	0.03	0.01
max	16.33	3.57	28.48
n	63	9	117

Table 2. Concentrations of T_4 in the blood serum of various age categories of cattle ($\mu g.dl^{-1}$)

	Calves	Heifers	Dairy cows
x	8.10[a]	9.15[a]	7.02[a]
sd	2.78	3.67	1.83
min	1.37	5.09	0.58
max	16.38	14.76	13.11
n	63	6	117

[a] values with the same superscript differ at $p<0.05$

When comparing blood serum concentrations of thyroid hormones of various age categories of cattle, we found significant differences in T_4 and T_3 values with the highest levels in heifers ($p<0.05$) (Tab. 2, 3). This could be probably related to lower metabolic load in heifers, which is indicated also by their lowest TSH values, although the differences were insignificant (Tab. 1, Fig 1). Mean concentrations of thyroid hormones in small ruminants are presented in Tables 4 and 5.

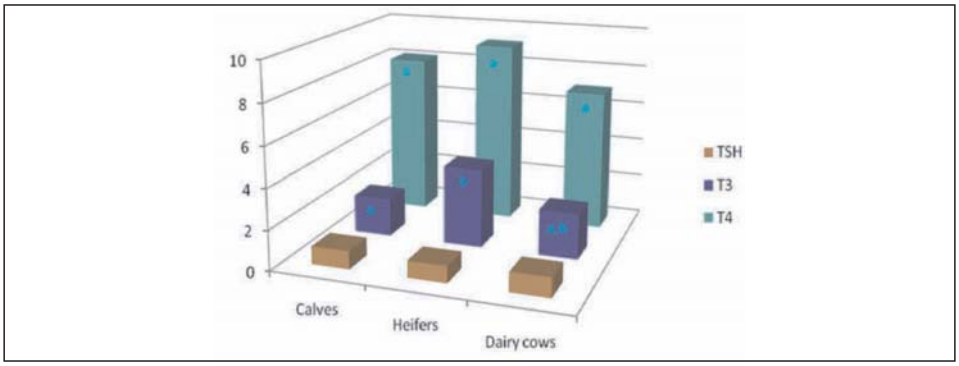

Figure 1. Concentrations of TSH ($mIU.l^{-1}$), T_4 ($\mu g.dl^{-1}$), and T_3 ($ng.ml^{-1}$) in the blood serum of various age categories of cattle
[a, b] values with the same superscript differ at $p<0.05$

Table 3. Concentrations of T_3 in the blood serum of various age categories of cattle ($ng.ml^{-1}$)

	Calves	Heifers	Dairy cows
x	1.91 [a]	3.92 [b]	2.28 [a,b]
sd	0.65	0.71	0.82
min	0.96	3.11	0.59
max	3.08	4.43	4.37
n	12	3	33

[a, b] values with the same superscript differ at $p<0.05$

Table 4. Concentrations of TSH and thyroid hormones in the blood serum of sheep and goats

	TSH ($mIU.l^{-1}$)	T_4 ($\mu g.dl^{-1}$)	T_3 ($ng.ml^{-1}$)
x	0.08	8.04	2.27
sd	0.21	2.26	0.96
min	0.03	3.86	1.33
max	0.86	11.38	3.81
n	14	14	8

Table 5. Concentrations of TSH and thyroid hormones in the blood serum of pigs

	TSH $mIU.l^{-1}$	T_4 $\mu g.dl^{-1}$	T_3 $ng.ml^{-1}$
x	0.24	4.08	1.42
sd	0.66	0.62	0.29
min	0.03	3.00	1.12
max	2.10	5.04	1.89
n	10	10	7

The results of age-dependent changes of thyroid hormones in young calves and piglets are presented in Tables 6 and 7. Concentrations of TSH in both calves and piglests showed no significant changes, however, most of the samples showed concentrations below the detection limit of the assay.

In the third month around calves' weaning, we found significantly lower serum T_4 concentration ($p<0.05$), compared with the initial value. Similar, but however insignificant decrease was observed for T_3 concentrations. After weaning, both T_4 and T_3 concentrations slightly increased (Table 6). Changes in T_4 concentrations during the observation period were significant ($p<0.05$).

Table 6. Concentrations of serum thyroid hormones in calves during first six months of age ($x \pm sd$)

Month	TSH $mIU.l^{-1}$	T_4 $\mu g.dl^{-1}$	T_3 $ng.ml^{-1}$
1	0.001 ± 0.003	9.06 ± 1.835 [a]	2.64 ± 0.915
2	0.017 ± 0.049	6.86 ± 1.237	1.59 ± 0.750
3	<DL	6.36 ± 0.759 [b]	1.67 ± 0.230
4	<DL	6.93 ± 2.754	1.87 ± 0.853
5	<DL	8.32 ± 1.980	2.22 ± 0.780
6	<DL	7.98 ± 1.756	2.23 ± 0.567
ANOVA	n. s.	$p<0.05$	n. s.

[a, b] values with different superscript differ at $p<0.05$
n. s. - non significant
DL detection limit (0.001 $mIU.l^{-1}$ for TSH)

In piglets, both T_4 and T_3 concentrations showed a significant ($p<0.001$) decrease during the study, when the highest mean concentrations of T_3 and T_4 were observed in youngest piglets. Similarly to calves, after weaning, concentrations of both hormones increased slightly (Table 7).

Table 7. Concentrations of serum thyroid hormones in piglets during first nine weeks of age (x ± sd)

Week	TSH mIU.l^{-1}	T_4 μg.dl^{-1}	T_3 ng.ml^{-1}
0	0.04 ± 0.132	11.73 ± 0.948^a	3.42 ± 0.097 ^{a}
1	0.01 ± 0.025	6.66 ± 0.694^b	2.25 ± 0.150^b
2	0.04 ± 0.132	6.08 ± 0.916^b	1.47 ± 0.232^b
3	0.05 ± 0.162	5.76 ± 0.971^b	1.12 ± 0.193^b
4	0.42 ± 1.093	5.13 ± 1.417^b	0.92 ± 0.217^b
5	<DL	4.96 ± 0.852^b	0.97 ± 0.427^b
6	0.00 ± 0.000	4.87 ± 0.730^b	1.23 ± 0.264^b
7	0.57 ± 1.411	3.83 ± 0.438^b	0.75 ± 0.186^b
8	0.22 ± 0.441	3.86 ± 0.568^b	1.33 ± 0.073^b
9	0.00 ± 0.000	4.41 ± 0.528^b	1.48 ± 0.182^b
ANOVA	n .s.	p<0.001	p<0.001

$^{a, b}$ values with different superscript differ at p<0.001
n. s. - non significant
DL detection limit (0.001 mIU.l^{-1} for TSH)

DISCUSSION

Available studies deal with concentrations of T_4 and T_3; therefore we have no data to compare with TSH values found in our observation. Moreover, most of samples showed concentrations below the detection limit of the assay. There is a need for species specific TSH tests. This might be useful, particularly in high-yielding dairy cows.

Table 8 presents concentrations of T_4 and T_3 in the blood serum of various categories of cattle, sheep, and goats published by several authors. Concentrations of T_4 and T_3 found in our observation in cattle correspond to the concentrations reported by other authors (Tiirats, 1997; Contreras *et al.*, 1999; Gvozdič *et al.*, 2008; Sinka *et al.*, 2008). Within our observation, concentrations of T_4 and T_3 found in sheep and goats are comparable with data of various authors (Kumar *et al.*, 1994; Lucaroni *et al.*, 1989).

In pigs, we found also T_4 and T_3 concentrations corresponding to published data (Dvorák *et al.*, 1986; Lefaucher and Etienne, 1991; Slebodzinski and Tratwal, 1988; Dvorák and Neumannová 1986; Yen and Pond, 1985; Nikolič and Živkovič, 1996; Schöne *et al.*, 1997) (Table 9).

When diagnosing long-term iodine deficiency, Whittaker (1999) suggested T_4 values below 1.56 μg.dl^{-1}, rather than below 3.9 μg.dl^{-1}. From this point of view, T_4 concentrations found in our study are sufficient as we observed a lower value only in one cow. This low value could indicate long-term iodine deficiency because plasma T_4 levels are relatively steady and do not reflect short-term changes in iodine intake. Thus, it is better to analyze plasma iodine, which reflects

current iodine intake (Rogers and Mee, 1996). However, its plasma concentrations change readily from day to day depending on dietary intake (Whittaker, 1999).

Table 8. Concentrations of T_4 and T_3 in the blood serum of various categories of cattle, sheep and goats according to various authors

Category/species	T_4 ($\mu g.dl^{-1}$)	T_3 ($ng.ml^{-1}$)	Reference
Calves under 3 months	8.21 ± 2.10	1.50 ± 0.48	Larson *et al.*, 1995
Healthy dairy cows	3.60 ± 1.10	1.22 ± 0.23	Đurđevic *et al.*, 1980
Dairy cows with ketosis	0.70 ± 0.40	0.83 ± 0.22	
Dairy cows 2 days after parturition	7.89 ± 15.8		Kesler, 1981
Dairy cows 5 – 6 days after parturition	23.50 ± 6.20		
Dairy cows	3.20 ± 0.90	0.91 ± 0.28	Contreras *et al.*, 1999
Low-yielding dairy cows 7 – 14 days after parturition	2.61 ± 0.51	1.47 ± 0.31	Gvozdić *et al.*, 2008
High-yielding dairy cows 7 – 14 days after parturition	2.55 ± 0.35	1.39 ± 0.27	
Low-yielding dairy cows 2 months after parturition	2.16 ± 0.41	1.29 ± 0.23	
High-yielding dairy cows 2 months after parturition	1.96 ± 0.42	1.06 ± 0.36	
Dairy cows 10 – 20 days before parturition	5.82 ± 0.67	1.11 ± 0.12	Sinka *et al.*, 2008
Dairy cows 15 – 20 days after parturition	2.88 ± 0.25	1.26 ± 0.12	
Dairy cows at peak of lactation	3.43 ± 0.55	1.27 ± 0.09	
Dairy cows at the end of lactation	4.99 ± 0.59	1.15 ± 0.06	
Umbrian goats under 1 year	8.65 ± 1.86	2.82 ± 1.01	Lucaroni *et al.*, 1989
Umbrian goats over 6 years	5.67 ± 1.81	1.57 ± 0.62	
Gaddi goats kept free on pasture	6.16 ± 0.37	1.62 ± 0.10	Kumar *et al.*, 1994
Gaddi goats kept on farm	4.96 ± 0.28	1.44 ± 0.10	

On the other hand, in pigs, Schöne *et al.* (1997) suggested serum concentrations of iodine and T_4 unsuited for diagnosis of iodine status as they may remain moderate even in the case of low iodine supply.

About age-dependent study of changes in thyroid hormones, in piglets we found both in T_4 and T_3 concentrations significant decrease during the study, when the highest mean concentrations of T_3 and T_4 were observed in the

youngest piglets. Similarly to calves, after weaning, concentrations of both hormones slightly increased.

Table 9. Concentrations of T_4 and T_3 in the blood serum of various categories of pigs according to various authors

Category	T_4 (μg.dl^{-1})	T_3 (ng.ml^{-1})	Reference
Newborn piglets	5.69 – 15.21		Dvorák *et al.*, 1986
Piglets 7-days-old	5.30 ± 0.56 7.16 ± 0.36	1.21 ± 0.11 1.5 ± 0.23	Lefaucher and Etienne, 1991
4.5 – 5.5-months-old	2.20 – 35.0	0.24 – 0.79	Slebodzinski and Tratwal, 1988
Weanlings	7.98 – 9.03		Dvorák and Neumannová 1986
Obese gilts	5.30 – 5.90	0.27 – 0.31	Yen and Pond, 1985
Lean gilts		0.45 – 0. 51	
Piglets 3 – 4 weeks post partum	3.90 ± 0.94	0.651 ± 0.26	Schöne *et al.*, 1997
	5.54 ± 1.09	1.11 ± 0.39	
Sows 3 – 4 weeks post partum	1.33 ± 0.39	0.13 ± 0.06	
	1.79 ± 0.62	0. 52 ± 0.06	
Sows in various reproduction stageň	2.71 – 4.31	0.73 – 0.85	Nikolić and Živković, 1996

Variations of T_3 and T_4 blood levels according to age have been described in many species including pigs. In nursed piglets, both hormone levels decrease during the first day of life (Herbein *et al*., 1977; Nowak, 1983; Slebodzinski and Cogiel, 1983) and remain fairly steady after 7-10 days of age (Slebodzinski *et al.*, 1981; Slebodzinski, 1986).

According to Dvorák *et al*. (1986), the thyroxinaemia of newborn piglets was twice that found in adult pigs and continued at a high level, with some variations, throughout the suckling period. By 3 weeks after weaning it had decreased, but still exceeded that found in 6-month-old feeder pigs. Slebodzinski (1979) reported plasma T_3 and T_4 levels being high in newborn piglets with dramatic decrease during the first postnatal weeks. Later on, they stabilized at levels 4 times lower than at birth.

Similarly, newborn calves show high concentrations of thyroid hormones, particularly in the first week of age, with their subsequent decreasing (Leirer and Dreschner, 1983). Tancin and Cupka (1991) investigated concentrations of thyroid hormones in calves within the first six months of age. During the studied period the average concentration of T_4 in the blood serum of calves ranged from 18.753 (1st day) up to 4.782 μg.dl^{-1} (63rd day) with the highest concentration of T_4 the first day of life. Similarly, the average concentration of T_3 ranged from 9.237 (1st day) up to 0.904 ng.ml^{-1} (118th day). In another study with newborn calves, Egli and Blum (1998) reported typically high levels of thyroid hormones at birth, which first rapidly and then more slowly decreased from day 0 to day 28.

Evaluation of thyroid hormones in animals is accompanied by several problems. The hormone blood concentrations are extremely variable. Moreover, data reported by various authors are obtained under different conditions and with the use of different analytical methods (Todini, 2007). Furthermore, although T_4 and T_3 are not species specific, analyses may be influenced by blood serum composition of corresponding species (Hanauer and Schroth, 1987).

Plasma thyroid hormones in lactating cows show circadian rhytmicity (Bitman *et al.*, 1994; Nazifi *et al.,* 2008), environmental factors like ambient temperature (Pratt and Wetteman, 1986; McGuire *et al.*, 1991), season (Tancin, 1991), dietary components and food intake (Awadeh *et al.*, 1998; Richards *et al.*, 1995; Tiirats *et al.*, 1997; Sharma *et al*., 2009; Feillet, 2010), or physical exercise.

Kumar *et al.* (1994) compared thyroid status between goats migrating freely on mountain pasture under varying climate conditions and animals kept on farms with regular feeding and only few hours daily grazing on pasture. In the free, migratory goats they found lower TSH levels and higher concentrations of T_4 and T_3, however, significant difference was observed only for T_4. Farm animals were exposed to lower physical exercise and milder climate.

Positive correlation between circulating thyroid hormones and energy balance is well known in many species including cattle (Kunz and Blum, 1985; Janam *et al.*, 1995; Leyva-Ocaricz *et al.*, 1997; Nikolič *et al.*, 1997; Capuco *et al.*, 2001; Cassar-Malek *et al.*, 2001). During post-partal negative energy balance (NEB), dairy cows respond by lowering T_3 and T_4 and increasing rT_3 concentrations (Ronge *et al.*, 1988; McGuire *et al.*, 1991). Kapp *et al.* (1978) suggested an important role of endocrine disorder, particularly thyroid, in pathogenesis of liver steatosis in high-yielding Holstein-Friesian dairy cows. The authors consider "fatty liver" syndrome as a consequence of hypothyreoidosis, when insufficient thyroid function (low serum levels of T_4 and T_3) leads to endocrine dysfunctions, liver disorders, and frequent puerperal complications. Decrease in circulating T_4 and T_3 hormones and functionless thyroid hypertrophy was observed in dairy cows suffering from adipose-hepatic fat syndrome (Kapp *et al.*, 1979). Presumably, there is protein-energy (or another) deficiency accompanied by obesity. This syndrome is associated with hormonal imbalance and metabolic disorders followed by reproduction disorders (stillbirths, retained placenta, metritis, low fertility).

Đurđevič *et al.* (1980) compared T_4 and T_3 levels in the blood serum of cows with and without ketosis. In dairy cows with ketosis they found significantly lower hormone levels: T_4 – 0.7 ± 0.4 *vs.* 3.6 ± 1.1μg.dl^{-1}; T_3 0.83 ± 0.22 *vs.* 1.22 ± 0.23 ng.ml^{-1}. Similarly, Djokovič *et al*. (2007) studied blood concentrations of thyroid hormones, lipids, glucose, and liver lipid content in dairy cows during the transitional period. In ketotic dairy cows, they suggested established hypothyroidal status. Kostopanagiotou *et al.* (2009) reported during acute liver failure markedly decreased serum thyroxin (T_4) and triiodothyronine (T_3) levels markedly decreased, whereas free-triiodothyronine and thyroxin-stimulating hormone levels did not change. T_4 and T_3 levels correlated with the degree of liver failure.

Also in pig, there seems to be relationship between energy metabolism and thyroid hormones. Yen and Pond (1985) compared thyroid hormones in genetically obese and lean pigs. While total T_4 concentrations were in these animals similar, obese pigs showed significantly lower T_3 concentrations than lean pigs, which may be related to lower fasting heat produced in obese pigs. Wiecek *et al.* (2010) observed higher blood T_3 concentrations in growing pigs receiving linseed oil diets throughout fattening.

Concentrations of thyroid hormones change significantly during the reproduction cycle. In accordance with nutritional and metabolic processes in advanced pregnancy, dried cows showed high concentrations of thyroid hormones followed by significant decrease in peri-partal period. Several authors reported lower T_4 levels in the beginning of lactation (Kesler *et al.*, 1981; Pethes *et al.*, 1985; Tiirats, 1987; Huszenica *et al.*, 2001; Sinka *et al.*, 2008) compared with late lactation.

Plasma concentrations of thyroid hormones in dairy cows may be affected also by other nutritional and metabolic facts like lack of selenium and/or iodine, eventually their supplementation (Wichtel *et al.*, 1996; Awadeh *et al.*, 1998; Dalir-Naghaden and Rezaei, 2008; Hefnawy and Tórtora-Pérez, 2010). Dalir-Naghaden and Rezaei (2008) recorded in lambs suffering from a Se- deficient myopathy significantly lower T_3 concentrations and higher levels of TSH and T_4. On the other hand, Matamoros *et al.* (2008) did not observe any significant changes in thyroid hormones in cows fed Se-deficient diet. Concentrations of thyroid hormones are also influenced by zinc deficiency. Zinc may affect binding of thyroid hormones and experimentally induced zinc deficiency may decrease circulating TSH and T_4 levels (Wada *et al.*, 1983).

Concentrations of thyroid hormones are also influenced by such factors like fat- or starch-enriched diet (Bunting *et al.*, 1996; Romo *et al.*, 1997; Blum *et al.*, 2000), and food contaminants, e. g. strumigenic substances (Gennano-Sofietti *et al.*, 1988; Bernal *et al.*, 1999; Thrift *et al.*, 1999a, b).

Following the aforementioned, evaluation of serum thyroid hormones requires either a strictly individual approach, or (at the level of herd diagnosis) precise specification of the selected groups of animals. Last but not least, there is a need for detailed research of thyroid disorders in farm animals under defined conditions.

ACKNOWLEDGEMENT:
This study was supported by VEGA scientific grant No.1/0614/09 of the Ministry of Education.

Address for correspondence:
MVDr. Iveta Paulíková, PhD.
Clinical Department for Ruminants
University of Veterinary Medicine and Pharmacy
Komenského 73
041 81 Košice, Slovakia
E-mail: iveta.paulikova@post.sme.sk

REFERENCES

1. *Awadeh FT*, *Kincaid RL*, *Johnson KA*, 1998, Effect of level and source of dietary selenium on concentrations of thyroid hormones and imunoglobulins in beef cows and calves, *J Anim Sci*, 76, 1204-15.
2. *Bernal A*, *De'Moraes GV*, *Thrift TA*, *Willard CC*, *Randel RD*, 1999, Effects of induced hypothyroidism on ovarian response to superovulation in Brahman (Bos indicus) cows, *J Anim Sci*, 77, 2749-56.
3. *Bitman J*, *Kahl S*, *Wood DL*, *Lefcourt AM*, 1994, Circadian and ultradian rhythms of plasma thyroid hormone concentrations in lactating dairy cows, *Am J Physiol*, 266, 1797-803.
4. *Blum JW*, *Bruckmaier RM*, *Vacher PY*, *Mûnger A*, *Jans F*, 2000, Twenty-four-hour patterns of hormones and matabolites in week 9 and 19 of lactation in high-yielding dairy cows feed tryglycerides and free fatty acids, *J Vet Med A*, 47, 43-60.
5. *Bunting LD*, *Fernandez JM*, *Fornea RJ*, *White TW*, *Froetschel MA*, *Stone JD et al.,* 1996, Seasonal effects of supplemental fat or undegradable protein on the growth and metabolism of Holstein calves, *J Dairy Sci*, 79, 1620-44.
6. *Capuco AV*, *Wood DL*, *Elsasser TH*, *Kahl S*, *Erdman RA*, *Van Tasel CP et al.*, 2001, Effect of somatotropin on thyroid hormones and cytokines in lactating dairy cows during ad libitum and restricted feed intake, *J Dairy Sci*, 84, 2430-9.
7. *Cassar-Malek I*, *Kahl S*, *Jurie C*, *Picard C*, 2001, Influence of feeding level during postweaning growth on circulating concentrations of thyroid hormones and extrathyroidal 5'-deiodination in steers, *J Anim Sci*, 79, 2679-87.
8. *Contreras PA*, *Wittwer F*, *Ruiz V*, *Robles A*, *Bohmwald H*, 1999, Blood values of thyroxine and triiodothyronine in grazing Friesian cows, *Arch Med Vet*, 31, 205-10.
9. *Dalir-Naghadeh B*, *Rezaei SA*, 2008, Assessment of serum thyroid hormone concentrations in lambs with selenium deficiency myopathy, *Am J Vet Res*, 69, 659-63.
10. *Delange F*, 1998, Screening for congenital hypothyroidism used as an indicator of IDD control, *Thyroid*, 8, 1185-92.
11. *Delange F*, 2000, In: Iodine deficiency, Braverman LE, Utiger RD, editors, *The thyroid: A fundamental and clinical text*, Philadelphia: Lippincott publ, 295-316.
12. *Delange F*, 2002, Iodine deficiency in Europe and its consequences: an update, *Eur J Nucl Med*, Supplement 2, 404-16.
13. *Djokovič R*, *Šamanc H*, *Jovanovič M*, *Nikolič Z*, 2007, Blood concentrations of thyroid hormones and lipids and content of lipids in the liver in dairy cows in transitional period, *Acta Vet Brno*, 76, 525-32.
14. *Đurđevič D*, *Stojić V*, *Jovanović MJ*, *Radaković N*, 1980, Concentration of Thyroxine, triiodothyronine and cortisol in the blood serum of ketotic cows, *Acta Vet-Beograd*, 30, 7-12.
15. *Dvorák M*, *Neumannová M*, 1986, Growth of weaned piglets and iodothyronine levels in the blood serum after the administration of thyreoactive substances, *Vet Med-Czech*, 31, 265-76.
16. *Dvorák M*, *Neumannová M*, *Bursa J*, 1986, The relationship of serum thyroxine level to body mass of piglets during their postanatal development, *Acta Vet Brno*, 55, 11-21.
17. *Feillet CA*, 2010, Food for Thoughts. Feeding Time and Hormonal Secretion, *J Neuroendocrinol*, 22, 620-8.
18. *Egli CP*, *Blum JW*, 1998, Clinical, haematological, metabolic and endocrine traits during the first three months of life of suckling simmentaler calves held in a cow-calf operation, *J Vet Med A*, 45, 45, 99-118.
19. *Gennano-Soffietti M*, *Nebbia C*, *Biolatti B*, *Re G*, *Castagnaro M*, *Cottino F*, *Guarda F*, 1988, Toxicology of fungicides: effects of 270 days administration of zinc-ethylene-bis-dithiocarbamate in Friesian cattle, *Schweiz Arch Tierheilkd*, 130, 657-72.
20. *Gvozdić D*, *Šamanc H*, *Kovačević B*, *Kirovski D*, *Fratrić N*, *Vujanac I et al.*, 2008, Endocrine status of holstein dairy cows with different milk production during late pregnancy and early lactation, Jubilee World Buiatrics Congress, 211.
21. *Hefnawy AE, Tórtora-Pérez JL*, 2010, The importance of selenium and the effects of its deficiency in animal health, *Small Ruminant Res*, 89, 185-92.

22. *Hanauer G.A*, *Schroth HJ*, 1987, Serum Effects on Thyroxine and Triiodothyronine Levels, *J Vet Med A*, 34, 790-7.
23. *Hemingway RG*, *Fishwick G*, *Parkins JJ*, *Ritchie NS*, 2001, Plasma Inorganic Iodine and Thyroxine Concentrations for Beef Cows in late Pregnancy and Early Lactation Associated with Different Levels of Dietary Iodine supplemetation, *Vet J*, 162, 158-60.
24. *Herbein JH*, *Martin RJ*, *Griel LC*, *Kavanaugh JF*, 1977, Serum hormones in the perinatal pigs and the effect of exogenous insulin on blood sugar, *Growth*, 41, 227-83.
25. *Huszenica GY*, *Kulcsar M*, *Nikolič JA*, *Schmidt J*, *Korodi P*, *Katai L*, *et al.*, 2001, Plasma leptin concentration and its interrelation with some blood metabolites, metabolic hormones and the resumption of cyclic ovarian function in postpartum dairy cows supplemented with monensin or inert fat in feed, In: Diskin MG, editor, Fertility in the High-producing Dairy Cow, British Society of Animal Science, Edinburgh: *Occasional Publications*, 2, 405-9.
26. *Janam J*, *Rudas P*, *Bartha T*, *Bozó S*, *Gábor GY*, 1995, Effect of severe energy restriction and refeeding on thyroid hormones in bulls, *Acta Vet Hung*, 43, 173-7.
27. *Kapp P*, *Pethes G*, *Zsíros M*, *Schuster Z*, 1978, Hypothyreogenic fatty liver syndrome in high-yielding dairy cows (In Hungarian). *Magyar Állatovorsok Lapja*, 10, 653-4.
28. *Kapp P*, *Pethes G*, *Zsíros M*, *Schuster Z*, 1979, Contribution to pathogenesis of fatty liver syndrome in high-yielding dairy cows (In Hungarian), *Magyar Állatovorsok Lapja*, 34, 458-69.
29. *Kesler DJ*, *Johnson HD*, *Garverick HA*, 1981, Postpartum concentrations of thyroxin in plasma of dairy cows, *J Dairy Sci*, 64, 1618-20.
30. *Kostopanagiotou G, Kalimeris K, Mourouzis I, Costopanagiotou C, Arkadopoulos N, Panagopoulos D et al*., 2009, Thyroid hormones alterations during acute liver failure: possible underlying mechanisms and consequences, *Endocrine*, 36, 198-204.
31. *Kumar N*, *Kumar R*, *Rastogi S*, *Singh SP*, 1994, Thyroid status of migratory and farm-managed Gaddi goats of Himachal Pradesh, *Indian J Anim Sci*, 64, 748-9.
32. *Kunz PL*, *Blum JW*, 1985, Relationships between energy balnces and bood levels of hormones and matabolites in dairy cows during late pregnancy and early lactation, *Z Tierphysiol Tierer*, 54, 239-48.
33. *Larsson B*, *Traven M*, *Hulten C*, *Hard Af Segerstad C*, *Belák K*, *Alenius S*, 1995, Serum concentrations of thyroid hormones in calves with a transieny or persistent infection with bovine viral diarrhoea virus, *Res Vet Sci*, 58, 186-9.
34. *Latham KM*, *Tseng YCL*, 1985, Nuclear thyroid hormone activities and serum iodothyronine levels in aging rats, *Age*, 2, 48-54.
35. *Lefaucher L*, *Etienne M*, 1991, Effect of exogenous thyrotropin-releasing hormone (TRH) administration on plasma levels of triiodothyronine (T_3), thyroxine (T_4) and growth hormone (GH) in chronically catheterized suckling piglets, *Domest Anim Endocrin*, 8, 601-9.
36. *Leirer R*, *Deschner F*, 1983, Pathophysiologische Untersuchungungen zur Schildreusenfunction des Kalbes. 2. Mitt. Schildreusenfunction beim klinisch gesunder Kalb, *Arch Exp Vet Med*, 37, 145-73.
37. *Leyva-Ocariz H*, *Lucciola K*, *Puzzar S*, 1997, Serum thyroid hormone concentrations during growth and puberty in Carora dairy heifers of Venezuela, *Theriogenology*, 48, 19-31.
38. *Lucaroni A*, *Todini L*, *Malfatti A*, *Debenedetti A*, 1989, Thyroid hormones blood level by the goat. Annual and diurnal variations. Effect if different physiological states, In: Greppi GF, Corti M, editors, Atti del Simposio Internazionale di Zootecnia: Piccoli Ruminanti oggi, Societa Italiana per il Progresso della Zootecnia, Milano: 91-104.
39. *Margarity M*, *Valcana T*, *Timiras PS*, 1985, Thyroxine deiodination, cytoplasmic distribution and nuclear binding of thyroxine and triiodothyronine in liver and brain of young and aged rats, *Mech Ageing Dev*, 29, 181-9.
40. *Matamoros R*, *Ceballos A*, *Contreras PA*, *Quiroga C*, *Andaur M*, *Wittwer F*, 2008, Serum concentrations of triiodothyronine, thyroxine and lipid profile in dairy cows fed with a low selenium diet, *Arch Med Vet*, 40, 23-9.
41. *McGuire MA*, *Beede DK*, *Collier RJ*, *Buonomo FC*, *De Lorenzo MA*, *Wilcox CJ*, 1991, Effects of acute thermal stress and amount of feed intake on concentrations of somatotropin insulin-like

growth factor (IGF)-I and IGF-II, and thyroid hormones in plasma of lactating Holstein cows, *J Anim Sci*, 69, 2050-6.

42. *Naidoo S*, *Timiras PS*, 1979, Effect of age on the metabolism of thyroid hormones by rat brain tissue in vitro. *Devel Neurosci-Basel*, 2, 213-24.
43. *Nazifi S*, *Saeb M*, *Hasankhani M*, *Ansari-Lari M*, *Ghafari N*, *Hasanshahi F*, 2008, Circadian variations in thyroid hormone levels of nonpregnant uniparous fat-tailed Iranian ewes in summer, *Turk J Vet Anim Sci*, 32, 137-40.
44. *Nikolić JA*, *Živković, B*, 1996, Possible effects of some parameters of reproductive success in sows to serum concentrations of thyroid hormones, insulin, IGF-1, cortisol and progesterone, *Acta Vet Beograd*, 46, 255-70.
45. *Nikolić JA*, *Šamanc H*, *Begović J*, *Damjanović Z*, *Đoković R*, *Kostić G et al.*, 1997, Low peripheral serum thyroid hormone status independently affects the hormone profiles of healthy and ketotic cows during the first postpartum, *Acta Vet Beograd*, 47, 3-14.
46. *Nowak G*, 1983, Free thyroid hormone levels during the postnatal period in the pig, *Biol Neonate*, 43, 164-71.
47. *Pethes GY*, *Bokori J*, *Rudas P*, *Frenyó VL*, *Fekete S*, 1985, Thyroxine, triiodothyronine, reverse-triiodothyronine and other physiological characteristics of periparturient cows fed restricted energy, *J Dairy Sci*, 68, 1148-54.
48. *Pratt BR*, *Wettemann RP*, 1986, The effect of environmental temperature on concentrations of thyroxin and triiodothyronine after thyrotropin releasing hormone in steers, *J Anim Sci*, 62, 1346-52.
49. *Richards MW, Spicer LJ*, *Wettemann RP*, 1995, Influence of diet and ambient teperature on bovine serum insulin-lieke growth factor-I and thyroxin: realtionships with non-esterified fatty acids, glucose, insulin, luteinizing hormone and progesterone, *Anim Reprod Sci*, 37, 267-79.
50. *Rogers PAM*, *Mee JF*, 1996, Trace element supplementation of cows, Part 1: Effects of oral copper, selenium and iodine supplements on tissue status, XIX World Buiatrics Conference, Edinburgh: 2, 394-7.
51. *Romo GA*, *Elasser TH*, *Kahl S*, *Erdman RA*, *Casper DP*, 1997, Dietary fatty acids modulate hormonal responses in lactating cows: mechanistic role for 5'deiodinase activity in tissue, *Domest Anim Endocrin*, 14, 409-20.
52. *Ronge H*, *Blum J*, *Clement C*, *Jans F*, *Leuenberger H*, *Binder H*, 1988, SomatomedinC in dairy cows related to energy and protein supply and to milk production, *Anim Prod*, 47, 165-183.
53. *Schöne F*, *Leiterer M*, *Franke K*, *Kinast C*, *Löser P*, *Lampe V et al*., 1997, Concentrations of iodine and thyroid hormones in sows and their offsprings (In German), *Deutsch Tierärztl Wschr*, 104, 461-500.
54. *Sharma MC, Joshi C, Das G*, 2009, Soil, fodder and serum mineral (cattle) and haematobiochemical profile in some districts of Central Uttar Pradesh, *Indian J Anim Sci*, 79, 411-5.
55. *Silva JE*, *Dick TE*, *Larsen PR,* 1978, The contribution of local tissue thyroxine monodeiodination to the nuclear 3, 5, 3-triiodothyronine in pituitary, liver and kidney of euthyroid rats, *Endocrinology*, 103, 1196-207.
56. *Sinka K*, *Illek J*, *Kumprechtová D*, *Novák P*, 2008, Changes T_3 and T_4 Plasma Concentrations in Dairy Cows during Lactation, Jubilee World Buiatrics Congress, 283.
57. *Slebodzinski AB*, 1979, Metabolic response to thyroxine in the newborn piglets, *Biol Neonate*, 36, 198-205.
58. *Slebodzinski AB*, *Cogiel F*, 1983, Serum thyroid hormone levels in colostrum deprived piglets and calves, *Endocrinol Exp*, 17, 263-70.
59. *Slebodzinski AB*, *Nowak G*, *Zamyslowska H*, 1981, Sequential observation of changes in thyroxine, triiodothyronine and reverse triiodothyronine during the postnatal adptation of the pig, *Biol Neonate*, 39, 191-99.
60. *Slebodzinski AB*, 1986, Perinatal thyroid activity in farm animals and the role of iodocompounds in maternal milk, *Endocrinol Exp*, 20, 229-46.

61. *Tancin V*, 1991, Vplyv ročného obdobia na hladiny tyeoidných hormónov a inzulínu v krvnom sére teliat, *Zivocisna Vyroba*, 36, 849-56.
62. *Tancin V*, *Cupka, P*, 1991, Concentration of thyroid-hormones in calves within the 1st 6 months, *Zivocisna vyroba*, 36, 755-62.
63. *Thrift TA*, *Bernal A*, *Lewis AW*, *Neuendorff DA*, *Willard CC*, *Randel RD*, 1999a, Effects of induced hypothyroidism on weight gains, lactation, and reproductive performance of primiparous Brahman cows, *J Anim Sci*, 77, 1844-50.
64. *Thrift TA*, *Bernal A*, *Lewis AW*, *Neuendorff DA*, *Willard CC*, *Randel RD*, 1999b, Effects of induced hypothyroidism or hyperthyroidism on growth and reproductive performance of Brahman heifers, *J Anim Sci*, 77, 1833–43.
65. *Tiirats T*, 1997, Thyroxine, triiodothyronine and reverse-triiodothyronine concentrations in blood plasma in relation to lactational stage, milk yield, energy and dietary protein intake in Estonian dairy cows, *Acta Vet Scand*, 38, 339-48.
66. *Todini L*, 2007, Thyroid hormones in small ruminants: effects of endogenous, environmental and nutritional factors, *Animal*, 1, 997-1008.
67. *Wada L*, *King JC*, 1986, Effect of low zinc intakes on bassal metabolic rate, thyroid hormones and protein utilization in adult men, *J Nutr*, 116, 1045-53.
68. *Whittaker DA*, 1999, Trace elements – the real role in dairy cow fertility? *Cattle Practice*, 7, 239-41.
69. WHO, UNICEF, ICCIDD, 2001, Assessment of the Iodine Deficiency Disorders and monitoring their elimination, Geneva: WHO publ., WHO/NHD/01, 1, 1-107.
70. *Wichtel JJ*, *Craigie AL*, *Freeman DA*, *Varela-Alvarez H*, *Williamson NB*, 1996, Effect of selenium and iodine supplementation on growth rate and on thyroid and somatotropic function in dairy calves at pasture, *J Dairy Sci*, 79, 1865-72.
71. *Wiecek J, Rekiel A, Skomial J*, 2010, Effect of feeding level and linseed oil on some metabolic and hormonal parameters and on fatty acid profile of meat and fat in growing pigs, *Arch Tierzucht*, 53, 37-9.
72. *Yen JT*, *Pond WG*, 1985, Plasma thyroid hormones, growth and carcass measurements of genetically obese and lean pigs as influenced by thyroprotein supplementation, *J Anim Sci*, 61, 566-72.

KONCENTRACIJA TIREOIDNIH HORMONA KOD RAZLIČITIH STAROSNIH KATEGORIJA PREŽIVARA I SVINJA

PAULÍKOVÁ IVETA, SEIDEL H, NAGY O, TÓTHOVÁ CSILLA i KOVÁČ G

SADRŽAJ

Cilj ovog istraživanja je bio da se odrede koncentracije tireoidnih hormona u krvnom serumu goveda, malih preživara i svinja različitih starosnih kategorija. Koncentracije TSH, T_3 i T_4 u krvnom serumu su određivane kod nasumično izabranih zdravih životinja različitih vrsta i starosnih kategorija. Promene u koncentraciji tireoidnih hormona, zavisne od starosti životinje, ispitivane su kod sedmoro klinički zdrave teladi tokom prvih 6 meseci njihovog života. Posmatranje je započelo u uzrastu od mesec dana kad su telad imala telesnu masu od 45 do 51 kg. Slično ispitivanje je izvršeno na devetoro prasadi na sisi u periodu od rođenja do 9 nedelja starosti (zalučene 35. dana). Uzorci krvi su prikupljani svake nedelje.

Kod teladi, junica i mlečnih krava registrovane su značajne razlike u vrednostima koncentracija T_3 i T_4, a najviše vrednosti su dobijene kod junica ($p<0,05$). Prosečne vrednosti koncentracije hormona kod ovaca, koza i svinja su bile podudarne sa onima koje navode drugi istraživači. U okviru ispitivanja uticaja uzrasta životinja, srednja vrednost TSH nije pokazivala značajne promene. Većina uzoraka je imala vrednosti ispod donje granice primenjenog eseja. U trećem mesecu, kod zalučene teladi, utvrđena je znatno niža koncentracija T_4 u serumu ($p<0,05$) u odnosu na početnu vrednost. Slično tome, zabeležen je i neznatan pad koncentracije T_3. Kod prasadi su koncentracije T_3 i T_4 ispoljile značajan pad ($p<0,001$) tokom ispitivanja a najviše srednje vrednosti koncentracija T_3 i T_4 je imala najmlađa prasad. Nakon zalučenja, koncentracije hormona su se blago povećavale i kod teladi i kod prasadi.