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The Effect of Ambient Temperature on Thyroid Hormones Concentration and Histopathological Changes of Thyroid Gland in Sheep

¹M. Nouri, ²K.H. Mirzadeh and ³B. Mohamadian

¹Department of Clinical Sciences, ²Department of Animal Science, ³Department of Pathology
College of Veterinary Medicine, Shaheed Chamran University, Ahvaz, Iran

Abstract: To identify the thyroid histological and hormonal changes in response to ambient temperature variations, thyroid glands and blood samples were randomly collected from 410 indigenous sheep of either sex and different age groups from municipal Ahvaz slaughter house. The extent of fluctuations in triiodothyronine (T_3), thyroxine (T_4), T_3 uptake and Free Thyroxine Index (FTI) and thyroid histopathological lesions were scrutinized in 2 months in year 2003, viz February (the coldest month) and August (the hottest month). A marked decline was discernable in T_3 , T_4 and FTI in August compared to February, but mean value for T_3 uptake increased. Out of 410 pairs of thyroid glands, 169 (41.2%) had lesions in which histopathological changes were categorized as follicular atrophy (43.6%), ultimobranchial cyst (30.2%), paranchymal cyst (6.4%), lymphocytic thyroiditis (6.2%), hyperemia/hemorrhage (5.5%), follicular cell hyperplasia (4%), C cell hyperplasia (1.4%), colloid goiter (1.1%) and adenoma (1.1). Mean of thyroidal parameters for T_4 and FTI was higher in lesioned group ($p < 0.05$). The frequency of lesioned thyroid was higher in summer than winter ($p < 0.05$). The result of this study showed that high ambient temperature has profound effect on thyroid function, secretion and pathological changes in sheep.

Key words: Ambient temperature, thyroid gland, hormones, histopathology, sheep

INTRODUCTION

Thyroid function of domestic animals is known to be altered by many environmental factors. Special attention has been given to the effect of ambient temperature (Hoersch *et al.*, 1961; Thompson *et al.*, 1973; Valtorta *et al.*, 1982) and feed intake (Yousef and Johnson, 1966; Singh *et al.*, 1971) on thyroid activity. The effects of exposure to high environmental temperature on blood thyroid hormone concentration in ruminants have been the subjects of numerous review articles. It has been shown in cattle that exposure to high environmental temperatures depresses thyroid activity whereas exposure to cool environments increases thyroid activity (Yousef and Johnson, 1966; Thompson, 1973; Johnson and Vanjonak, 1976; Young, 1981; Pratt and Wettemann, 1986). In experiments carried out with sheep, it was shown that blood thyroid hormone (T_4) concentration decreased gradually between the 40th and 80th day of exposure to 32°C (Sanchez and Evans, 1972).

In experiments with sheep it has been shown that exposure to cool environments increased feed intake and thyroid hormone concentration (Ingram and Mount, 1975). In another study in cattle, it has been found that a decreased feed intake caused by exposure to a high environmental temperature is correlated with a decrease in

T_4 (Yousef and Johnson, 1966). It has been reported that increase in ambient temperature depresses feed intake in sheep and results in decrease in plasma T_4 concentration, but temperature per se appears to provide an additional depression in the reduction of plasma T_4 levels (Valtorta *et al.*, 1982).

There is little debate concerning the relationship between ambient temperature and histological changes in the thyroid gland in rat but unfortunately, there is not any study indicating the effect of temperature stress on thyroid gland pathological changes in ruminants. This lack of information, underlines the need to determine the relationship between ambient temperature and histological and hormonal changes in the thyroid glands of these animals that is the main aim of the current study.

MATERIALS AND METHODS

The research was carried out in Ahvaz, capital of Khuzestan province, a city in the south of Iran, 800 km to Tehran, the capital, with very high temperature in summer and a mild climate in winter. Ahvaz is among the hottest cities in Iran and even in the world and its temperature in summer reaches 50°C and some days even more than 60°C in the sun. In this study blood samples

and thyroid glands were collected randomly from 410 sheep slaughtered at Ahvaz municipal abattoir. The sheep in the area were at all times subjected to outdoor environment temperature and exposed to solar radiation throughout the day during grazing time. The age of the animals ranged from below 6 months to above 48 months. The entire period of study was classified into two months in year 2003 with very different temperatures; February with minimum and maximum temperatures 1 and 23.5°C, respectively and relative humidity 70% and August with minimum and maximum temperatures 23 and 50°C, respectively and relative humidity 51.67% were the months we collected our samples.

After collection, the blood samples were allowed to stand for 20-30 minutes and then they were centrifuged at 2000 to 3000 rpm. The serum was separated and stored at -22°C till assayed. Serum T₃, T₄ and T₃ uptake were determined by the standard Radio Immuno Assay (RIA) method according to the protocol described in the commercial kits of Kavoshyar, Radim and Diazorin, respectively.

After macroscopical examination, all thyroid glands were fixed in 10% formaldehyde for 24-48 h, dehydrated in an ethyl alcohol series (70, 80, 90, 100, 100-I, 100-II %) and embedded in paraffin wax. Sections were cut and stained with Hematoxylin and Eosin, Periodic Acid Schiff-Hematoxylin and by Gallego's method (McManus and Mowry, 1968).

RESULTS

Analysis on blood samples showed significant differences of total T₃, T₄, T₃ uptake and FTI between February and August (Table 1). Total T₃, T₄ and FTI decreased in August compared to February (p<0.05) while T₃ uptake showed significant increase.

Among 410 thyroid glands divided equally in two groups of 205, 169 revealed some pathological changes under light microscopy which equals 41.2% of all samples (Table 2). Among all pathological changes, 41.4 and 58.6% were in February and August, respectively; In other words, 34.1% of thyroid samples in February and 48.3% of samples in August had some pathological changes, which was significantly different (p<0.05). Furthermore in Table 3, the incidences of specific types of pathological changes are demonstrated.

On the other hand, evaluation of the effect of these pathological lesions on thyroid function showed significant increase in thyroid function in the presence of pathology (Table 4). Only follicular cell hyperplasia was accompanied by significant increase in total T₃, T₄ and FTI (p<0.05). Also hyperemia/hemorrhage resulted in significant total T₄ increase (p<0.05). Ultimobranchial cyst was the only one significantly associated with T₃ uptake increase (data not shown). For more information, each pathologic lesion is shown and discussed in brief in Fig. 1.

Table 1: Thyroidal indices in sheep slaughtered in Ahvaz abattoir

	Total T ₄ (µg/100 mL)	T ₃ Uptake (%)	FTI (µg/100 mL)	Total T ₃ (ng/100 mL)
February	6.46±0.16	31.65±0.29	1.85±0.05	106.8±2.97
August	5.50±0.13	33.65±0.24	1.65±0.39	84.33±2.39
p-value	<0.001	<0.001	0.002	<0.001

Table 2: Number and incidence of pathological lesions in sheep in February and August

	Total (Feb and Aug)	February	August
Number of lesioned samples	169.00	70.00	99.00
Sample size	410.00	205.00	205.00
Incidence of pathologic lesions (%)	41.20	34.10	48.30
Distribution of pathologic lesions (%)		41.40	58.60

Table 3: Incidence of pathological lesions in thyroid glands in February and August

	Follicular atrophy	Ultimobranchial cyst	Paranchymal cyst	Hyperemia and hemorrhage	Follicular cell hyperplasia	C cell Hyperplasia	Adenoma	Colloid goiter	Lymphocytic thyroiditis
Feb	39.0	25.0	13.0	12.0	10.0	2.0	2.0	3.0	3.0
Aug	81.0	58.0	6.0	3.0	1.0	2.0	1.0	0.0	14.0
Distribution in all lesions (%)	43.6	30.2	6.9	5.5	4.0	1.4	1.1	1.1	6.2

Table 4: Thyroidal indices based on the presence of pathological lesions

	Total T ₄ (µg/100 mL)	T ₃ uptake (%)	FTI (µg/100 mL)	Total T ₃ (ng/100 mL)
Lesioned	6.30±0.17	32.98±0.31	1.86±0.05	97.26±3.09
Normal	5.76±0.13	32.43±0.32	1.68±0.04	94.38±2.59
p-value	0.010	0.164	0.007	0.475

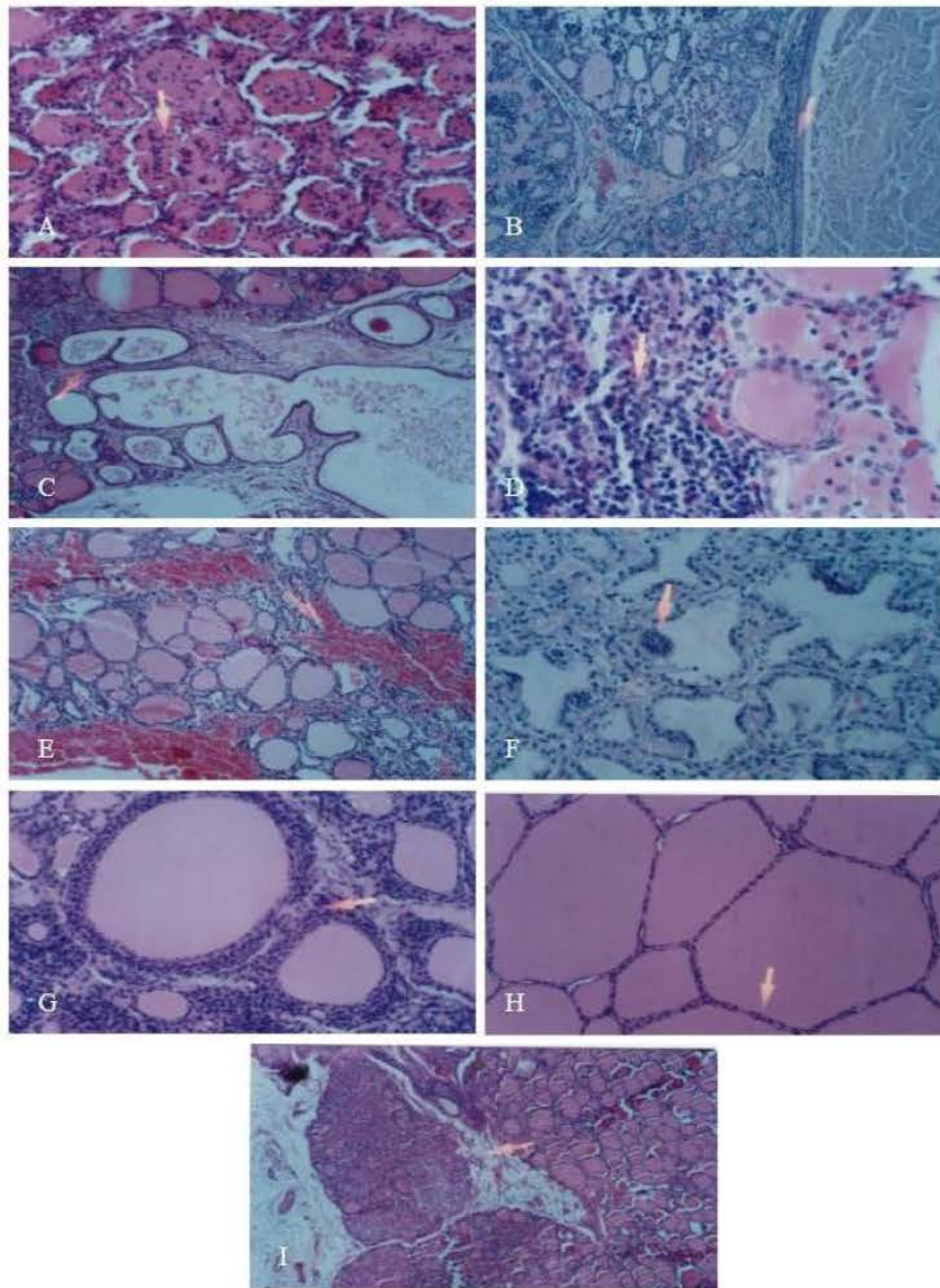


Fig. 1: Light microscopy sections demonstrate wide variety of pathological changes in thyroid glands: Follicular atrophy showing small follicles contained small quantity of colloid (A), Ultimobronchial cyst with stratified squamous epithelial cells (B), Paranchumal cysts where some are too distended and ruptured (C), Lymphocytic thyroiditis showing lymphocyte infiltration (D) Hyperemia and bleeding between follicles (E), Follicular hyperplasia seen in some follicles (F), C cell hyperplasia (G), colloid goiter with large follicles contained eosinophilic colloid (H), Follicles cell adenoma which is similar to normal tissue and separated by a fibrotic (I) (H and E, A×266; B×1333; C×133; D×532; E×133; F×266; H×266; I×532)

DISCUSSION

It is well known that among environmental factors, two factors more importantly affect the blood level of thyroid hormones: Ambient temperature and feed intake (Grossie and Turner, 1962; Sutherland and Irvine, 1974; Evans and Ingram, 1977). High temperature and decreased feed intake have been shown to decline thyroid hormone via various mechanisms (Portnay *et al.*, 1974; Panda and Turner, 1975; Szabo and Frohman, 1975; Hefco *et al.*, 1975; Vagenakis *et al.*, 1977; Suda *et al.*, 1978). Notably, it has been proposed that temperature plays a dual role in between: Its direct effect on TRH and subsequently plasma T_4 (Valtorta *et al.*, 1982) and indirect effect on decreasing appetite which on its own can decrease thyroid hormone blood level. So, whether high temperature independently suppresses thyroid hormone may raise controversy. To shed some light on it, Yousef and Johnson (1960) proclaimed that even the force-fed cattle showed a significant decrease in thyroid activity when subjected to the heat treatment. For reconfirmation, Valtorta *et al.* (1982) ran a study contained a heat-stressed group compared with control and feed-restricted groups which showed temperature effect was additional to the feed effect and the heat-stressed group displayed a significantly greater decline in plasma T_4 . Based on these studies, we come to the point that although feed restriction has a great impact on plasma levels of thyroid hormone, we can not ignore the dramatic independent effect of ambient temperature. One aim in this study was to compare the effect of temperature, a hot month versus a cold month, on the thyroid hormones and as it could be prognosticated, our experience revealed significant decreased blood levels of T_4 , T_3 and FTI in August compared to February (Table 1). Since the animals were fed *ad libitum*, we do not claim that we have eliminated the intake effect as a confounding factor, but according to the evidence given above, we announce that differences observed in our study, were *mostly* due to the high temperature effect not decreased food intake.

More interestingly, not mentioned previously in literature, samples collected in August were affected more frequently than those obtained in February (Table 2). A wide spectrum of pathological changes were observed in these lesions depicted in Table 3 among which follicular atrophy and ultimobranchial cyst, which compose 73.8% of all lesions, worth being more addressed. These pathologic changes can not be simply attributed to the increased TSH level in August, which may lead to pathologic lesions, due to decreased T_4 level. This is not in favor of current belief which indicates that T_4 level

changes indirectly due to the effect of temperature on TRH level, not as a direct effect of temperature on enhancing T_4 release or production and so we should expect a nadir in TSH level in summer not a peak which does not help us to interpret these results. Whether this increase in pathological changes is due to effect of temperature on TRH, TSH or thyroid hormones levels remains a matter of controversy which needs further studies.

From functional point of view, there were significant alterations in hormone levels based on pathologically free or affected thyroid. As it can be elicited with casting a furtive glance over Table 4, all changes are in the same direction and indices are higher in pathologically affected group. This may seem in contrast to the fact that T_4 and T_3 uptake changes should be in opposite directions trying to keep FTI in the normal range. But we should take notice that data shown in Table 4 representative for all samples and as each sample has its own increase or decrease in T_4 and opposite change in T_3 uptake, their overall effect can be in any direction based on the number of samples in any direction and the spectrum of changes.

Last thing which attracted our attention was the high incidence of pathologic changes in thyroid glands in both seasons and the high levels of T_3 , T_4 and FTI in this study in comparison to other reports around the world (Sutherland and Irvine, 1974; Valtorta *et al.*, 1982; Maharajan *et al.*, 1982; Guerrini and Bertchinger, 1983). Although some variations like age, altitude and breed can explain these differences, we are to evaluate the iodine content of the sheep's feed intake and the soil of the area in which they graze. Apart from that, we are to reconfirm our data by comparing iodine-intake controlled groups from different geographical zones in Iran.

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