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A SURVEY ON SERUM THYROXINE LEVEL OF HOLSTEIN LACTATING AND NON-LACTATING COWS IN A TROPICAL ENVIRONMENT

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ABSTRACT

W. Chia-Mo Wan and Pi-Hsueh Li (1971). *A Survey on Serum Thyroxine Level of Holstein Lactating and Non-lactating Cows in a Tropical Environment.* Bull. Inst. Zool., Academia Sinica **10**(2): 97-102. Holstein dairy cows living in a tropical environment (Taiwan, Rep. of China) were subjected to a survey on serum thyroxine (T_4; in μg/100 ml serum) level in correlation with the variations of environmental temperature (temp). Data of Holstein pure breed cows at lactating non-pregnant (HM) and non-lactating non-pregnant (HD) stages were presented. The T_4 level tends to be lower at a higher temp. Significant correlations were found in HM group ($P<0.01$). In HD cows, a negative correlation existed between T_4 and temp, when the temp range was at 16 to 22°C ($P<0.01$). Serum T_4 data between 24-29°C demonstrated an elevation with temp increase, but was not significant ($P>0.05$). However, a significant difference ($P<0.01$) was found in average T_4 values between ranges 21-22° and 28-29°C (4.33 ± 0.28 and 5.89 ± 0.30, respectively), suggesting that there is a high temp limit for thyroid function in response to environmental temp via hypothalamic-temperature sensitive mechanism. No lower limit was observed. Within the same temp range, the T_4 is significantly higher in HD cows (5.60 ± 0.23 at 16-20°C; 5.09 ± 0.24 at 25-29°C) than in HM cows (4.79 ± 0.31 at 16-20°C; 3.37 ± 0.16 at 25-29°C) ($P<0.001$).

Numerous studies have demonstrated that heat exposure depresses the thyroid activity (2, 9, 10, 11, 13, 15). In dairy cows, Premachandra *et al.* (11) found that the thyroxine secretion rate (TSR) had a three-fold decrease during the summer months in Missouri (U. S. A.) climatic conditions. Only few works concerning the serum thyroxine (T_4) measurements in cattle have been presented (8). The present survey is attempting to correlate the variations of serum T_4 level in Holstein dairy cows with the environmental temperature (temperature) changes in tropical area.

MATERIALS AND METHODS

Eighteen pure breed Holstein cows with assorted ages (2-11 years old) were used in this survey. A year-round (July 1, 1970 to June 30, 1971) jugular blood samples for lactating non-pregnant (M) and non-lactating non-pregnant (D) cows were collected by vacuum blood collector. The sera were then separated and stored in a deep freezer (-20°C) till the time for analysis. The dates for blood collection were arranged according to the temperature variations of the locality where the herd is subsisted [Taiwan Provincial Livestock Research Institute (TPLRI), geographically, Lat. 23°4′ N, Long. 120°26′ E, Altitude 31 M].

The feeding ration was the regular formula of TPLRI and had the following composition:

Maintenance feeding

Corn mix:	corn	50%
	cotton seed meal	30%
	salt (crude)	5%
	bone meal	15%
	(1 kg/cow/day)	
Urea:	100 gm/cow/day	
Molasses:	2 kg/cow/day	

Supplementary feeding: cows producing more than 4.5 kg milk per day will be fed 1 kg more of the mix for every additional 2 kg milk produced.

Roughage was mainly napier in spring and summer (*ad lib*), and was substituted with sugar cane top in winter (35-40 kg/cow/day).

Iodine contents of the ration were not determined.

The serum T_4 was determined according to the method of competitive protein-binding analysis introduced by Murphy and Pattee (9). The material used was purchased from Abbott Laboratories (North Chicago, Illinois, U.S.A.) as Tetrasorb T_4 diagnostic kit.

It was found that the serum T_4 showed a depression during calving interval, and gradually returned to the original level at about 30 days after calving (Wan and Do, in preparation). Thus, the T_4 values were chosen from 30th day after calving for lactating group. The data of milk production (kg/day) of these cows also collected.

Pooled bovine serum samples were also analyzed for T_4 for checking the data obtained from individual samples. All of the T_4 data of a certain analytical run would be eliminated if the data in that run was outside that of the pooled serum T_4 mean$\pm$2 S.D. (12).

RESULTS

A year-round temperature records of TPLRI for the monthly highest and the lowest are given in Table 1. It can be divided into four sections, namely, (a) warmer season, started at the very first days of May, (b) descending period, started in early October, (c) cooler season, began in early December, (d) ascending period, began in the middle of March.

Serum T_4 decrease in correspondence with temperature increase was observed (Table 2). In lactating cows a correlation was found at a significant level of $P<0.01$. In non-lactating cows a highly significant

TABLE 1

Environmental Temperature (monthly highest and lowest, °C) at Taiwan Provincial Livestock Research Institute, Shin-Hwa, Taiwan, R.O.C., 1970-1971

Month	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Hi.*	38.2	35.9	37.3	36.4	36.9	35.0	35.2	34.2	30.3	34.2	33.8	36.8
Lo.	21.5	23.0	23.7	23.5	24.0	15.5	11.8	7.4	5.5	3.0	13.0	10.7

* Hi: highest; Lo: lowest

negative correlation was found in the temperature range from 16 to 22°C ($P<0.01$). A positive T_4 elevation with temperature increase was observed above 24°C, but was not significant (Fig. 1).

Serum T_4 values were higher in the low temperature range and in non-lactating cows (Table 3). The milk production showed a

TABLE 2
Correlation Analysis of Serum T_4 of Holstein Dairy Cows and Environmental Temperature (16-29°C)

Group*	Temp range (°C)	No. of Observ.	Intercept. (a)	Slope (b)	r	P
M	16-29	60	6.925	−0.125	−0.392	<0.01
D	16-29	92	6.195	−0.048	−0.134	NS
	24-29	45	1.440	+0.138	+0.173	NS
	16-22	47	12.299	−0.374	−0.418	<0.01

* M: Lactating nonpregnant; D: Non-lactating nonpregnant

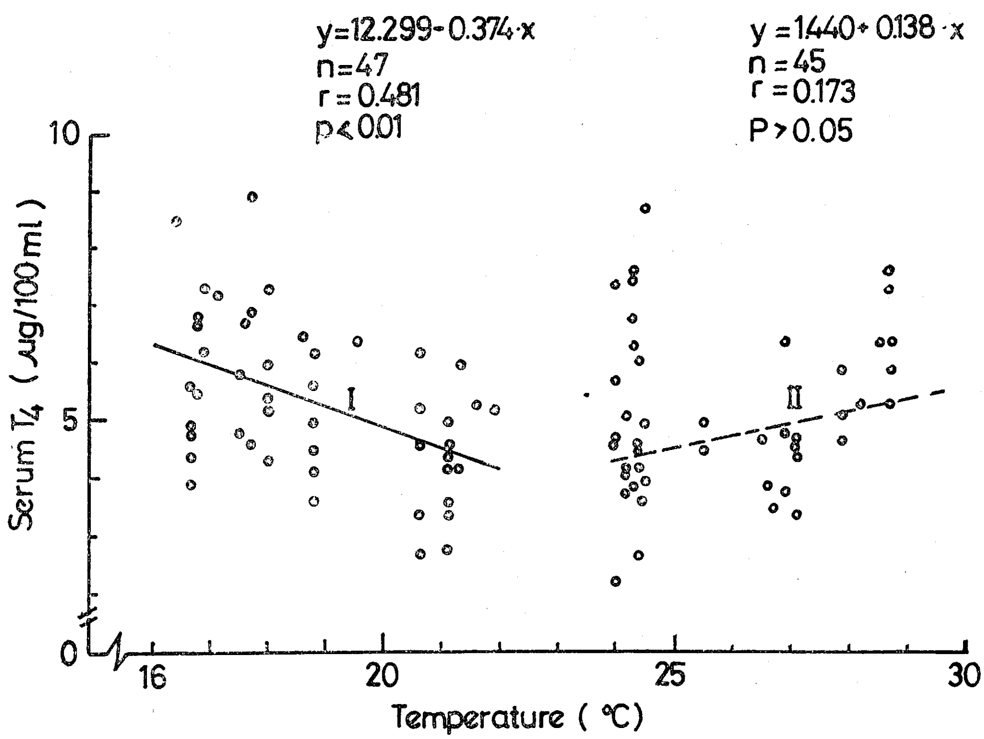

Fig. 1. Variations of serum T_4 level in correlation with daily average temperature in Holstein non-lactating nonpregnant cows, I) solid line showed a negative significant correlation; II) dot line showed a positive nonsignificant correlation.

TABLE 3
Serum T_4 of Holstein Dairy Cows in Different Temperature Range (μg/100 ml)

Groups*	Temperature Range, °C	
	16-20	25-29
M	4.79±0.31[a] (19)[b]	3.37±0.16[c] (15)
D	5.60±0.23[d] (30)	5.09±0.24[c,d] (22)

* M: Lactating.
D: Nonlactating.
a Mean±S. E.; significant difference was tested by Student t-test.
b Numbers of observations.
c High temperature *vs.* low temperature range in the same group ($P<0.001$).
d Between M and D group, $P<0.001$.

significant correlation with serum T_4 (Table 4). The present survey did not provide enough data for analyzing the influence of age.

DISCUSSION

In the two groups of Holstein non-pregnant dairy cows, the lactating cows showed a significant negative correlation between serum T_4 and temperature in the observed range of 16 to 29°C. The non-lactating cows, however, showed same significant correlation but in the range of 16 to 22°C (Fig. 1, Table 2). The occurrence of depressed thyroid activity in higher environmental temperature agreed with most of the observation on livestock and rats (2, 3, 6, 11, 13). In non-lactating cows the T_4 values showed a tendency of increase with the temperature increase in the range of 24 to 29°C, but was not significant. Nevertheless, a significant difference ($P\ll 0.01$) was found between the average T_4 values of temperature range 21-22° and 28-29°C (4.33±0.28 and 5.89±0.30 μg/100 ml, respectively), with the higher temperature range showing higher value. These findings agreed with previous investigation on rats (1,4) and cattle (15). It was suggested that the hypothalamic-temperature sensitive mechanism will operate only within an environmental temperature limit the thyroid activity will be depressed under a high temperature. In the present report, only the upper limit was observed in non-pregnant non-lactating cows, which is in the range of 22-24°C.

Some of the investigations for the farm animals were performed in northern part of U.S.A. (2, 6, 10, 11) where the variation of environmental temperature level is different from that of the present survey. One report (10) on cattle thyroid activity as influenced by temperature recorded the range as 27-76°F (or -3 to 24.5°C) in Missouri, U.S.A. The daily average temperature range for the present study in TPLRI is 9-28.8°C (absolute monthly highest and lowest ranged 3-38.2°C). It seems that no correlation study has been made on serum T_4 with environmental temperature variations in cows of temperate zone. It is therefore rather hard to find results comparable with the present study. However, Lorscheider *et al.* (8) reported that

TABLE 4
Correlation Analysis of Milk Production *vs.* Serum T_4 in Holstein Dairy Cows

Nos. of cows	Nos. of observ.	Milk prod. (Kg/day)	Intercept. (a)	Slope (b)	r	P
7	50	8.40±1.40* (4—14)**	11.882	−0.661	−0.378	0.01

* Mean±S. E.
** The range of milk production.

less milk producing Holstein cows (28 lb/day≅12.7 kg/day) with 3 months pregnant in Michigan, U.S.A., gave a T_4 value (5.64±0.30) higher than that of the Holstein cows living in Taiwan area (4.79±0.31) with a similar milk yield (12.2 kg/day) at the temperature of 16-20°C. Since temperature record was not given for the Michigan cows, this comparison may only indicate a tendency that the cows in the tropical area give a lower T_4 value.

It is known that the quantity of milk production affects the serum T_4 value of cows (7, 8). It was found that the non-lactating cows gave a higher T_4 values than lactating cows within the same temperature range (Table 3). It was also found in this laboratory that the T_4 value showed a significant depression right after calving and would not return to the original level for 30 days (Wan and Do, in preparation). Although in the present report are included only the T_4 values of the cows with low milk production (8.40±1.40 kg/day, ranged 4-14 kg/day) and of the cows 30 days after calving, still the data showed significant correlation between T_4 and milk production (Table 4). Thus, the decline of T_4 in the lactating cows may be the result of the combined effect of high temperature and milk production.

In measuring the TSR of dairy calves, Lewis *et al.* failed to find a significant lowering in the summer season (5). Johnson *et al.* (4) found that prolonged exposure to heat eventually caused rats to have a persistently elevated thyroidal I^{131} release rate and histologically hyperactive thyroid glands. Yousef *et al.* reported that an initial protein bound iodine (PBI) increase was observed (15) when cattle were exposed to heat (38°C). Bakke and Lawrence (1) demonstrated that exposure to heat (39°C) caused an increase in pituitary thyroid stimulating hormone (TSH) content, and, sometime, in serum TSH in male rats. In the present report a tendency of T_4 elevation in Holstein non-lactating cows with a temperature increase in higher temperature range (24-29°C) was observed (Fig. 1 and Table 2), and, significant difference ($P<<0.01$) was found in average T_4 values between ranges 21-22° and 28-29°C as mentioned. The actural highest temperature of the warm season may reach 38.2°C. Thus, the cattle exposed in this heat may elevate the thyroid activity. In addition, the T_4 values of non-lactating cows in the temperature range of 16-22°C manifested a significant negative correlation ($P<0.01$). Since the T_4 level in these cows are not significantly influenced by physiological conditions such as milking and pregnancy, the temperature effect may, as well, be more clearly demonstrated. This phenomenon seems to suggest that temperature affects thyroid activity via hypothalamic-temperature sensitive mechanism only up to a certain temperature level. Beyond this level, the activity may no longer follow the heat-hypothalamus-TSH release inhibition control mechanism. The present report provided no information concerning lower temperature limit.

Johnson *et al.* (4) reported that no apparent proportional increase in metabolic or calorigenic value with a greater I^{131} release at an elevated temperature could be observed in rats. This may give other reason for the elevated T_4 level in non-lactating cows in heat. Because animals exposed to heat may voluntarily reduce their food intake, this variability was studied by Johnson and Yousef (3). They found in cattle that PBI was not affected by short-term fasting and suggested that the increase in thyroid activity in fasting animals at 1°C compared with 18°C was dependent mainly on environmental temperature and not on feed intake. In rat they also found (14) that when control rats were restricted to the same amount of food as eaten by the heat exposed rats, both groups showed similar thyroid activity. Thus, anorexia during heat-exposure may be one of the reasons in altering thyroid function.

The present investigation suggests that

in non-lactating cows there is a high temperature range which thyroid activity fails to follow the hypothalamic-temperature sensitive mechanism. The high level of T_4 found in these cows may be caused by either increase of production or by decrease of utilization or both.

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