

The Effects of Tropical Climate Stressor on Gamma Immunoglobulin Concentration of Serum and Colostrums of Dairy Cows of First and Second Parity

(Pengaruh Cekaman Iklim Panas terhadap Konsentrasi Imunoglobulin Gama Serum dan Kolostrum Sapi Perah Pariti Satu dan Dua)

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Abstract. The new born dairy calves serum containing extremely low antibodies (Ig) or nothing at all. This means that their livability or mortality greatly depend on the antibody especially IgG of cow's colostrums to sustain their passive immunity. An observation and analytical study was conducted to evaluate the effects of tropical climate stressor (TCS) on immunoglobulin gamma (IgG) concentration in three different climate locations in term of temperature (°C) and humidity (%). Those dairy farming locations were: (1) the cold or temperate climate in sub-district Tutur, (2) the moderate climate in sub-district Purwodadi and (3) the hot climate in sub-district Grati. Those three sub-districts are belong to District Pasuruan—East Java Province, Indonesia. For these purposes sample of 93 cows were determined using purposive sampling method and 29-33 blood samples (1.0 ml) of late pregnant cows (2–3 weeks pre partum) and colostrums samples (1,0 ml) from respective location were collected. Blood samples were measured for cortisol concentration (nmol/L) using radioimmunoassay (RIA) procedure and IgG serum and IgG kolostrum concentration (mg/ml) were measured using direct ELISA. The study was then set up to ensure factorial experimental design and conducted over summer season. SPSS for Window statistic program was applied to necessary statistical analysis. Results indicated: (1) Evidence of TCS significantly effected ($P<0.05$) the blood cortisol levels of the cows which was the lowest in the cold (22.28 mg/ml) and the highest in the moderate location (54.07 mg/ml), (2) TCS was also affected IgG serum concentration ($P<0.05$) the lowest in moderate climate (4.76 mg/ml) while between cold and hot climate was not different significantly, and (3) TCS did not decline concentration of IgG colostrums ($P>0.05$) but a tendency that IgG colostrums concentration in hot climate was the lowest. The results suggest that low level of IgG in hot and moderate climates as being critical and efforts must find out to elevate IgG colostrums concentration to provide adequate passive immunity and at the same time preventing calves mortalities.

Key Words: tropical climate stressor, cortisol, serum, colostrum, gamma immunoglobulin

Introduction

Colostrums is obviously needed by newborn calf, since it containing a lot of immunoglobulin (Ig) while calf doesn't has mother's antibodies at birth. So calf survival and morbidity rate is greatly depend upon the quality and the amount of colostrums produced by the cow and to passively transfer her immunity from the dam to her offspring (Arthington *et al.*, 2000; Quigley *et al.*, 2002)

There are varieties of Ig bovine colostrums such as Gamma Immunoglobulin (IgG₁ and IgG₂),

IgA, IgM, IgD, IgE. Besides, colostrums is also containing growth factors, hormones, etc. The most abundant Ig in colostrums is IgG. This fraction is considered as a very important if not the only important part of the colostrums (Hammer *et al.*, 2004).

More recent studies stated that many factors influencing Ig colostrums concentration such as genetic (breeds), climates, age, and parities (Morin *et al.*, 1997 and Jaster, 2005). Colostrums from colder climate areas such as from New Zealand was better in respect to Ig concentration, than those colostrums produced

from cows in the hotter climate locations (Nardone *et al.*, 1997). In relation to this finding, Moore *et al.* (2005) reported specifically that colostrum collected immediately after calving and early collection time may account for the high colostrum IgG concentration. Older cows and cows that have had more progenies were considered to produce better colostrums quality. In addition the quality of nutrition, especially at *prepartum* greatly determine the quality of colostrums (Arthington *et al.*, 2000).

Epidemiologic studies (Hartwig, 1996), proved that calf mortalities 5.1-20.2% between 1–5 weeks and of those figure 60–70% occurred at the age 10 days. Risk rate (RR) for morbidity and mortality was reported from tropical country of Kuwait (in Midle east) was 0.59 ± 0.35 and 0.38 ± 28 , respectively (Razzaaque *et al.*, 2009). In East Java (Indonesia), calf mortalities 3.88% of the total cows population, or around 12.09% (SD 5.99%) of the total birth per year (Wartomo, 1990). Rate of morbidity reported by Witjaksono, 1998, amount of 9.8% of the total birth per year. In addition, calves don't have enough antibodies at birth, the high mortality and morbidity are also due to inadequate colostrums antibodies received by the calves during milking. This means that passive immunity is greatly determined by the adequacy of Ig colostrums from the dam.

Stressor is considered as any adverse condition or influence which tend to disrupt the normal, steady functioning of the body and its parts, and generally is adverse to its well-being (Nardone *et al.*, 1997). Tropical climate is one of stressor on dairy Friesian cows generally being kept by farmers in Indonesia. The main element of climate that inducing stressed on dairy cows is daily high temperature in combination with high humidity (%). A stressed cow will be more suffered if the cow in late pregnancy. Physiological and biological consequent under heat stressor is the suppression immune system, mobilization of muscle and liver glycogen in order to sustain life and also shrinking thymus and lymphoid tissues. The suppression of immune system is caused by declining of lymphoid tissue activities and declining the number of lymphocyte B cells which is responsible to the production of antibody and T cells killer (Julie *et al.*, 1998) This statement then in agreement with Lippolis (2008) stated that immunne system is impaired under

heat stress, especially neutrophil and lymphocyte functions.

So far cortisol, IgG serum and IgG colostrums concentration of late pregnant Friesian cows under tropical climate stressor (TCS) in Indonesia, have not yet understood accurately. Thus, the objectives of this study are to investigate the effects of TCS on IgG serum and IgG colostrums concentrations. This information is important and needed to provide adequate passive immunity to new born calves and minimize mortality.

Research Methods

Observational and analytical studies in combination with factorial model, were conducted to investigate the effects of tropical climate stressor (TCS) on IgG serum and IgG colostrums concentration of dairy Friesian in three different tropical climate locations (Wijaya, 2001). Climate (temperature and humidity) data were obtained from the office of Meteorology and Dairy Cooperative in District of Pasuruan, East Java.

Locations and Climate Characteristics

Three sub-district location highly populated with dairy cows were selected in District of Pasuruan (East Java-Indonesia). Climate characteristic of those locations are presented in Table 1.

Cows Samples

A total of 93 late pregnant cows (2–3 weeks before expected birth) was collected from farmers, so there were 31 cows sample of each sub-district. Purposive sampling method was applied to collect samples (Wijaya, 2001). Description of cow samples included: (a) age between 2.5–3.5 years old, (b) expected to have first (P_1) and second calving (P_2), (c) free from clinical sign of mastitis (d) having normal birth or without any assistance, and (e) their body condition score were about similar.

Variables

Research variables divided into two, including, independent variable comprised of : climate (a combination of temperature, °C and humidity, %) of each location. Dependent variables included: (a) blood cortisol hormone concentration, (b) blood (serum) IgG concentration and (c) IgG

colostrums concentration. In addition control over feed and feeding arrangement, water supply and type of cow houses were also conducted to minimize interfering variables.

Data Collection

Blood sample of 93 cows, or about 1.0 cc each, were taken out from *auricular* venous and collected in micro tube then divided by two parts. One part of 0.5 cc was examined to measure its IgG concentration using radioimmunoassay procedure. In addition a total of 93 colostrums samples were also collected and analysis to measure the IgG concentration. Both examinations were conducted at Virology Laboratory Faculty of Veterinary Medicine, Airlangga University, Surabaya. The other part of 0.5 cc blood samples were examined to measure cortisol hormone concentration (nmol/L) using Direct Elisa method and conducted at Reproductive Health and Endocrinology

Laboratory Dr Soetomo General Hospital, Surabaya (East-Java).

Statistic Analysis

Data were analysed by two-way analysis of variance with a model that included parameters locations (climates), cortisol hormone concentration, IgG serum concentration and IgG colostrums concentration either in first (P_1) or in the second (P_2) calving and their interactions. Linear regression by cortisol hormone was determined by the least squares method using GLM procedure SPSS 10 (Wijaya, 2001).

Results and Discussion

Table 2, shows mean of cortisol, IgG serum and IgG colostrums concentrations in three different climate locations.

Cortisol Concentration

Cortisol hormone concentrations in three locations are presented in Table 2.

Table 1. Climate characteristics of the three sub-district (locations) of observation

No	Climate components	Name of sub-districts		
		Tutur (CCL)	Purwodadi (MCL)	Grati (HCL)
1	High above sea level	700 – 2000 m	370 – 700 m	10 m
2	Daily temperature (°C)	16 – 25°C	20 – 28 °C	24 – 34 °C
3	Daily humidity (%)	50 – 70%	60 – 80%	70 – 80%
4	Rain fall (mm/year)	3.650 mm	1.800 mm	288 mm

Meteorology office of District Pasuruan

CCL = cool climate location, MCL = moderate climate location, HCL = hot climate location

Table 2. The effects of TCS on cortisol, IgG serum and IgG colostrums concentrations in three locations

No	Variables	Locations (climates)			Remarks (P)
		Cool (CCL)	Moderate (MCL)	Hot (HCL)	
1	Cortisol concentration (nmol/L)	22.28 ^a (10.48)	54.07 ^b (11.57)	41.16 ^c (16.86)	P = 0.000
2	IgG serum concentration (mg/ml)	5.00 ^a (0.14)	4.76 ^b (0.42)	5.09 ^a (0.19)	P = 0.001
3	IgG colostrum concentration (mg/ml)	18.3895 ^a (6.64)	19.36 ^a (6.54)	17.98 ^a (5.14)	P = 0.648

Means within a row with no common superscript differ significantly (P<0.05)

Values within brackets are SD

Cortisol concentrations were significantly difference ($P=0.00$) which was the lowest in CCL (Sub-District of Tutar), and the highest in MCL (sub-district of Purwodadi). These facts strongly indicated that cows in both locations have been considered under stressed. Daily temperature ($^{\circ}\text{C}$) and humidity (%) in both locations showed higher than the dairy cow's ideal (Table 1) temperatures was $16\text{--}25^{\circ}\text{C}$ as stated by Nicola *et al.* (2005). The increased of cortisol in hotter environments in this study in agreement with the study of West (2003), that hot climate changed corticosteroid hormone including cortisol. Other studies supported this finding, that glucocorticoid (GC) hormone produced more rapidly by sympathetic nervous activities or pass through hypothalamus–cortex–adrenaline axis (Selk, 1998 and Mehrzad *et al.*, 2001). However the extend of TCS as indicated by cortisol concentration was not linearly with the climates characteristics of the locations (Table 2). These facts possibly due to cows adaptive response after long period of chronic heat stressed in sub-district of Grati. This facts were supported by the study Ronchi *et al.* (2001). That, under acute heat stress conditions, the initial shock causes a rise in cortisol secretion, followed by an adaptation phase under chronic conditions in which cortisol levels are reduced to normal physiological levels. Originally Friesian cows in this location were first introduced hundred years ago or since the Dutch colonization in Java, Indonesia. While dairy farming in Sub-district Purwodadi has been relatively new, or more recently than farming activities in sub-district of Grati, District of Pasuruan.

IgG Serum Concentration

There were also evidences that TCS decreased the IgG serum concentrations in MCL and HCL which differ significantly ($P<0.05$). An addition the decreased pattern of those figures in Table 2 were also in association with cortisol hormone concentration. Cortisol concentration was the highest in MCL and was associated with the lowest IgG serum ($P = 0.01$). However, there was no difference statistically between IgG concentration in CCL and HCL ($P>0.05$). Study conducted by Mehrzad *et al.* (2001), stated that the increase of corticoid hormone due to stressor, had caused immune system suppression

by lowering lymphoid tissues activities. The results showed the number of lymphocyte cells which were responsible of producing antibodies and T-cells or killer T cells decreased. Nardone *et al.* (1997), stated that high air temperature over the final 2 weeks of pregnancy had lower mean concentration of IgG and IgA. The effects of stressors on livestock in particular pregnant dairy cows had been studied by Selk (1998) and she stated that poor management, induced physiological changes especially in immune system. The non significant results of IgG serum concentration ($P>0.05$) between CCL and HCL was interested. It was possibly due to adaptive plasticity in the brain of cows in HCL after long period of chronic stress. This finding was in agreement with the study Arave *et al.* (1996^b), that heat stress increase the glucocorticoid levels and reduced neutrophil functions.

IgG Colostrums

Data IgG colostrums in Table 2, indicate non significant effect ($P>0.05$) of TCS, although there was a descending tendency of IgG concentration toward HCL. West (2003), previously stated that the increase of cortisol hormone caused by heat stressor, changed metabolism activities of cells in mammary glands, primarily due to the decrease of energy supplied (esp. glucose). These were an interesting facts along with argumentations could be forwarded to clarify IgG colostrums concentrations: (1) The gradually decreased of IgG concentrations (Table 2), were not associated with pattern of average values of IgG serum, which was the lowest in MCL. This facts could be understood for indeed IgG colostrums level varies greatly (2-23%) from the total Ig colostrums (Morin *et al.*, 2001). The widely variation of IgG colostrum concentration were not merely depends on the amount transfered from the blood stream, but also partly could be determined by nutritive quality, since it's was difficult to get good quality forage (grasses) in HCL. A previous study (Muller and Ellinger, 1981), reported a mean colostrum IgG concentration 41.2 g/L for 19 Holstein cows. So the finding of this present study (Table 2) much lower and belong to the poor colostrum quality. (2) The declined IgG concentrations in MCL and HCL were not in association with the blood cortisol concentration in the three locations (Table 2). The different

patterns of responses of the cows in MCL and HCL, could be explained by understanding a key mechanism involves the stress-hormone dependent translocation of immune cell in the blood to tissues and organs where an immune defense is needed. In mastitis cases, or involution phase of mammary glands, IgG are able to pass through the tight junction (transfer between the two epithelial cells), to the lumen of alveoli. There fore the amount of IgG colostrums in MLC might increase (Oliver, 1998). This finding was supported by Bambang (2003) (Dairy cooperative staff, personal communication) who had been reported that so many cases of mastitis found in Purwodadi dairy milk co-operative.

The related study (Bradely, 2002), supported this present study, that up to 4 millions somatic cells was found in case of mastitis of dairy herd under poor management than only 1–2 millions somatic cells in non mastitis cows.

More recent study by Larson *et al.* (1990), stated, the existance of HET (heat stress) impaired the transfer of IgG from blood stream to the udder. These were the reasons why, the pattern of relation between plasma IgG concentration were not in association with colostral IgG concentration in hot and moderate climate location as compared with the pattern relation in cool (CCL).

Mean while study from Maunsell *et al.* (1998) reported that colostrum from multiparous Holstein cows with or without mastitis contained 78 up to 80 g of IgG/L. These finding supported the present experiment data that colostrum from mastitis cows as were found in moderate climate (MCL) higher than in hot locations (HCL).

Adaptation

The effects of TCS on IgG concentrations were also evaluated in the first and second paritiies. With respect to IgG colostrums and IgG serum, statistical analysis found no significant differences ($P>0.05$) in three locations (climates). Collier *et al.* (2006) stated that, after long period of suffering chronic stress, the measurable response of the cow is probably adaptation “which is an adjustment to the new or modified surrounding” Carpenter statement was related with facts that cows in HCL (Sub-district of Grati) had been bred for years since Dutch colonization in Indonesia (Zainal, 2003, Head of Sukamakmur Dairy

Cooperative of Sub-district Grati, District of Pasuruan, personal communication). In this present study adaptation had been measured by interactions between parities first and second including IgG concentrations with locations (CCL, MCL and HCL).

The non significant differences of IgG concentration between parities indicated that good management practices at fist and second calving have been minimized the adverse effects of TCS, hence the cows were less susceptible to extremes temperatures. In addition, the non significant interactions or the negative adaptation in this present study, as consequence overlapping of climate characteristics (temperatures and humidity) in three locations (Table 1).

Conclusions

The results suggest that low level of IgG serum and colostrums quality as indicated by cortisol and Ig concentration in moderate and hot climates are being critical to survival rate of calves. There fore efforts must find out to elevate IgG colostrums concentration to provide adequate passive immunity and at the same time preventing calves morbidity and mortalities.

References

- Arthington J, MB Cattell and JD Quigley. 2000. Effect of dietary IgG source on effcienency of absorption in newborn Holstein calves. *J. Dairy Sci.* 83:1463–1467.
- Arave CW, ML Sipka, J Morrow and JL Albright. 1996. Change in serum cortisol following extended lock – up time of lactating cows. *J. Dairy Sci.* 79 (supp 1): 191.
- Bradely. 2002. Bovine mastitis : anevolving disease. *Veterinary Journal* 164(2):116-128.
- Collier RJ, GE Dahl, and MJ VanBaale. 2006. Mayor advances associated with environmental effects on dairy cattle. *J. Dairy Sci.* 89: 244-1253.
- Hammer CJ, JD Quigley, L Riberio, and HD Tyler. 2004. Characterization of a colostrum replacer and colostrum supplement containing IgG concentration and growth factors. *J. Dairy Sci.* 87(1): 106-111.
- Harthwig NR. 1996. Controlling infection diseases of the dairy calf. *Veterinary Extension*.
- Jaster. 2005. Evaluation of quality, quantity, and timing of colostrum feeding on immunoglobulin G1 absorption in Jersey calves. *J. Dairy Sci.* 88(1): 296-302.

- Julie MT, W Neal and H George. 1998. Respon of Gamma Delta T-lymphocytes to heat stress in *B Taurus* an *B Indicus* crossbed cattle. Tektran (Agricultural Research Service), Clay Center, USA.
- Larson BLHL, Jr Heary and JE Devey. 1990. Immunoglobulin production and transport by the mammary gland. *J. Dairy Sci.* 63:665.
- Lippolis. 2008. Immunological signaling network: Integrating the body's immune response. *J. Anim./ Sci.* 86: E53-E63.
- Maunsell FD, DE Morin, PD Constable, WL Hurley, GC McCoy, L Kakoma, and RE Usaacson. 1998. Effects of mastitis on the volume and composition of colostrum produced by Holstein cows. *J. Dairy Sci.* 81 :1291-1299.
- Mehrzad JD. 2001. Respiratory burst activity of blood and milk neutrophils in dairy cows during different stage of lactation. *J. Dairy Res.* 68: 399-415.
- Moore M, JW Tyler and M Chigerwe. 2005. Effect of delayed colostrum collection on colostral IgG concentration in dairy cows. *J. Am. Vet. Med. Assoc.* 226: 375-1377.
- Morin DE, GC McCoy, and WL Hurley. 1997. Effects of quality, quantity and Timing of colostrum feeding and addition of a dried colostrum supplement on immunoglobulin G1 absorption in Holstein bull calves. *J. Dairy Sci.* 80(4): 747-753.
- Morin DE, PD Constable, and FP Maunswll. 2001. Factor associated with colostral specific gravity in dairy cows. *J. Dairy. Sci.* 84:937-943.
- Muller LD and DK Ellinger. 1981. Colostral Immunoglobulin Concentration Among Breeds of Dairy Cattlle. *J. Dairy Sci.* 64 (8) : 1727-1730.
- Nardone A, N Lacetera, U Bernabucci and B Ronchi. 1997. Composition of colostrum from dairy heifers exposed to high air temperature during the late pregnancy and the early pospartum period. *J. Dairy Sci.* 80: 838-844.
- Nicola L. 2005. Lymphocyte functions in dairy cows in hot environment. *International J. Biometeorology* 50(2).
- Oliver. 1998. Overview of lactation. *J. Anim. Sci.* 320.
- Quigley JD, CJ Kost and TM Qwollfe. 2002. Absorption of Protein and IgG in Calves fed a colostrum supplement or replacer. *J. Dairy Sci.* 85: 243-1248.
- Razzaque M, S Abas and M Bedair. 2009. Mortality of pre-weaned calves in Kuwait's dairy Herds, Its causes and impact of interventions. *J. Vet. Med.* 5(2).
- Ronchi B, G Stradaioli, A Verini, U Bernabucci, N and Lacetera. 2001. Influence of Heat Stress or Feed Restriction on Plasma Progesterone, Oestradiol-17B, LH, FSH, Prolactin and Cortisol in Holstein Heifers. *Livest. Prod. Sci.* 68(2-3): 231-241.
- Selk G. 1998. Prenatal stress on suckling calves (Research Update). Ansci Facts.
- Wartomo H, S Haryati dan A Budiarto. 1990. Evaluasi Pencapaian Target Pelita V Bidang Sapi Perah di Jawa Timur. Proc. Seminar Nasional Peningkatan Efisiensi.
- West JW. 2003. Effects of heat stress on production in dairy cattle. *J. Dairy Sci.* 86: 2131-2144.
- Wijaya IR. 2001. Analisis Statistik dengan Program SPSS 10.0. Penerbit Alfabeta, Bandung, hlm 65-84.
- Witjaksono BF. 1998. Laporan : Praktek Kerja Lapangan di Balai Kehewanan Wilayah III Surabaya KUD Suka Makmur Nongkojajar KUD Dana Mulya Pacet Taman Ternak Pendidikan FKH Unair Surabaya. Fakultas Kedokteran Hewan, Universitas Airlangga, Surabaya.