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Original Article

Biochemical studies on the impact of external and blood parasites on milk production and it`s components in dairy cattle.

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ABSTRACT

External and internal parasites are the major cause of many problems in dairy cattle. This study estimated the association of external parasites infestation and blood parasites infection with milk production and it`s components. Identification and prevalence of ticks, *Babesia* and *Theileria species* were carried out on 300 local moderate lactating Friesian cattle .The effect on chemical components of milk and other milk parameters including amount and immune suppression were studied. 75% of dairy cattle were infested with ticks while 9% were infected with *Babesia spp.* and 10% were infected with *Theileria spp*. , levels of both calcium and zinc in serum of dairy cattle infested with ticks , infected with *Babesia spp.* and infected with *Theileria spp.* were markedly decreased (9.3±0.5, 8.7±0.6 & 9.2±0.7 mg/dl) respectively for calcium and (0.37±0.001, 0.23±0.001 &0.31±.001 µg/dl) respectively for zinc . Ig E levels were increased in dairy cattle infested with ticks (1.7±0.03 µ/ml), infected with *Babesia spp.* (1.1±0.02 µ/ml) and infected with *Theileria spp.* (1.2±0.02 µ/ml) than clinically healthy ones (0.95±0.02 µ/ml). Significantly decreased Calcium levels in milk of dairy cattle infested with ticks , infected with *Babesia spp.* and infected with *Theileria spp.* (144.5±13.8, 129±12.3 & 132±11.4mg/dl) respectively than that of clinically healthy ones (159.4±12.7mg/dl). Also zinc levels in milk recorded decreasing values in dairy cattle infested with Ticks, infected with *Babesia spp.* and infected with *Theileria spp.* (8.5±0.07, 6.9±0.8 & 7.2±0.6 µ mol/dl) respectively than that of clinically healthy ones(12.7±0.09 µ mol/dl).

Keywords: Dairy cattle, ticks**,** blood parasites, milk production, Ca, zinc, Ig E.

INTRODUCTION

Dairy cattle play significant role in meat and milk production by converting feed into these highly valuable products. External Parasites cause economic losses in dairy industry **(Marwat et al., 1988)** as it has negative impact on health and production of animals **(Sanchez et al., 2002),** by robbing cattle of its nutrients requirement, increasing animal stress and being vectors for other diseases causing lower milk yield **(Charilier et al., 2009) .** External Parasites can be detected by naked eye for both clinical or sub-clinical manifestation **(Wiszniewska et al., 2021).**Ticks are ectoparasites that attach to its host causing irritation to the skin **(Minjauw**

and McLeod 2003), ticks infestation is very important due to their direct effects such as blood loss, damage to skins, and debilitation, causing great losses to the livestock industry**(Grech-Angelini 2016; Oundo et al.,2024)** reducing feed intake, feed efficiency, milk production and pregnancy rate in mature cows also act as vector for blood parasites **(Strickland 2013; Sotiria et al., 2022),** causing severe problems in cattle as it has bad effects on immunity leading to economic losses**, (Alam and Nasar 2011),** but severe tick infestation doesn´t reflect the extent of the infection of tick born blood parasites **(Wijeweera et al., 2017).** Babesiosis is tick-borne hemolytic disease caused by intraerythrocytic protozoan parasites of genus *Babesia* (**Abdel Aziz et al., 2014; Tana-Hernández et al., 2017; Hailemariam et al., 2017).** Theileriosis is another important tick-borne disease affecting cattle caused by *Theileria spp.* belonging to the phylum Apicomplexa **(Ota et al., 2009)** causing decreased milk production **(Eamens et al., 2013; Khatoon et al.,2015)**. Referring to the role of external and blood parasites in the change of chemical component of milk including allergen specific IgE, all allergens are recorded down to a cutoff level of 0.10 KU/L, the significance of allergen specific IgE levels between 0.10-o.35 KU/L remains undefined, individual allergen specific IgE antibody levels may not always correlate with severity of clinical symptoms but quantitative IgE levels can serve to guide overall. About 50% of food protein absorption take place in duodenum, it diffuse paracellularly through the epithelial layer, due to the enhanced permeability by the action of several pro-inflammatory cytokines **(Heyman and Desjeux 2000)**, food proteins reach the MALT (mucosa associated lymphoid tissue) in large quantities leading to IgG induction and immune complexes. So, the food-adverse reactions are not IgE mediated but may be immunologic **(De Meo et al., 2002).** In these cases a cell-mediated response determines local changes with a release of specific cytokines and activation of TH2 lymphocytes (secreting IL-4, IL5, IL10 and IL13), that promote the production of Ig E and amplify the inflammatory response (eosinophils, mast cells, neutrophils and natural killers chemotaxis), causing morphological and functional alteration of the mucosa **(Sabra et al., 2003**). There are different mechanisms that contribute to the pathogenesis and the main two described mechanisms at the basis of this disease refer to IgE and not IgE reactions **(Strobel 2001).** The interaction among allergens on mast-cells/basophiles and IgE antibodies promotes an intracellular signaling process with a consequent cell degranulation and a release of histamine, Platelet-activating factor (PAF) and other inflammatory mediators **(Braga et al., 2011).** It is noticed that a deficiency in regulation and polarization of milk specific T cells toward type-2 T helper cells(TH2) lead to B-cell signaling to produce milk protein-specific Ig E **(Beyer et al., 2002**). It is known that the highest demands for the calcium are produced during the periods of maximum growth such as in childhood, also during lactation and in elderly; this need recommended dietary allowance for calcium by food nutrition board is 1300mg per day for adolescents 1100mg per day for adults (**Mahan and Stump 2002**). There are a few reports available on natural zinc deficiency in ruminant, this could be due to the facts that pastures rarely contain<20mg zinc Kg/ DM, zinc deficiency are increased calcium and phosphorus intake decrease zinc absorption **(Suttle and Jones 2007**). In ruminants, normal serum zinc levels are between 11-18 mg/dL and animals with levels below 10.5mg/ dL are considered deficient, **(Fouda et al., 2011)** found that the parasitic

infestation causes variation and changes in blood picture as serum composition with reduce of zinc concentration level among infested calves.

MATERIALS AND METHODS

Animal examination

300 local moderate lactating Friesian cattle were examined during free veterinary medical convoys in different cities of Dakahlia Governorate for presence of external and blood parasites. All cases included in this study were free from bacterial , viral infection , helminth and protozoal parasites as animals were subjected to clinical examination to eliminate bacterial and viral infected cases as possible as we can ,all suspicious cases were denied from the study, also fecal samples were obtained directly from rectum ,packed in clean plastic containers , numbered and transferred to Mansoura laboratory for parasitological examination to eliminate cases with helminth or protozoal parasites.

Collection of samples

Ticks were collected directly by thumb forceps from infested areas (neck, back, ear, tip of tail, perineal region and udder) of examined cattle, collected parasites were placed into plastic tubes containing 70% ethyle alcohol solution for morphological identification (Alkareem 2012).

Blood samples for blood parasite examination

Blood samples were collected from tail vein of examined animals in tubes with EDTA, transferred to Mansoura laboratory for preparation of thin blood film, according to **Feldman et al., 2000,** examined by light microscope under oil immersion lens (x100) **(Saleem et al., 2014),** blood parasites were identified according to **Soulsby (1982)**.

Blood samples for biochemical analysis

10 ml Collected blood from jugular vein were divided into 2 parts, 5ml in each tube with EDTA for complete blood picture analysis by using auto hematology Analyzer KT.60 China, and other 5ml placed into plain tubes without anticoagulant to separate serum, the tubes were kept inclined position for15 min at room temperature, centrifuge at 3000 rpm for 10 min to separate clear serum samples then stored in Eppendorf tubes and kept frozen until use in biochemical analysis **(Lobetti et al., 2000).**

Biochemical analysis

All biochemical parameters were estimated by using Biochemistry analyzer (Prietest CMPACT, India). While IgE levels were estimate using Specific Protein Analyzer (Mispa i2) depending on dual measuring technology (rate-based nephelometry and immunoturbidimetry).

Milk samples

Milk samples were analyzed via Frank Gerber 98 lacto star milk scan apparatus. The concentrations of fat, protein, lactose, salts, total solids, pH and density were determined. Quantitative determination of calcium and zinc was carried out using wet digestion method by "Buck scientific 210VGP Atomic Absorption Spectrophotometer" at Central Laboratory of Faculty of Veterinary medicine, Zagazig University.

Sensory evaluation

Milk samples were examined for color, smell and texture **(Clark et al., 2008).**

Statistical analysis

One-way ANOVA tests followed by Duncan tests were used to compare the effect of ticks, *Babesia spp. and Theileria spp.* on Calcium, Zinc and IgE levels in serum, blood picture, milk chemical constituents, and produced amount of milk of examined dairy cattle. Data were expressed as Mean ± standard error (SE).

RESULTS

Parasitological examination

Parasitological examination for presence of external parasites revealed that out of 300 dairy cattle, 225 were infested with ticks, 75 were free from external parasites **(table 1).**

Clinical signs

Ticks infestation

Ticks ***(****Rhipicephalus annulatus*) were found on legs, belly, neck, dewlap ,back and shoulders, while Adult ticks (Hyalomma spp.*)* were attached on the inner thighs and udder **(**Figure 1).Infested animals exhibited skin irritation, ulceration, restlessness, significant loss of weight , and decrease in milk production, some infested animals showed fever (41- 41.5^{0}C) with anorexia ,hemoglobinuria pale mucus membranes and some others showed fever with enlarged lymph nodes, lacrimation, eye opacity and respiratory distress.

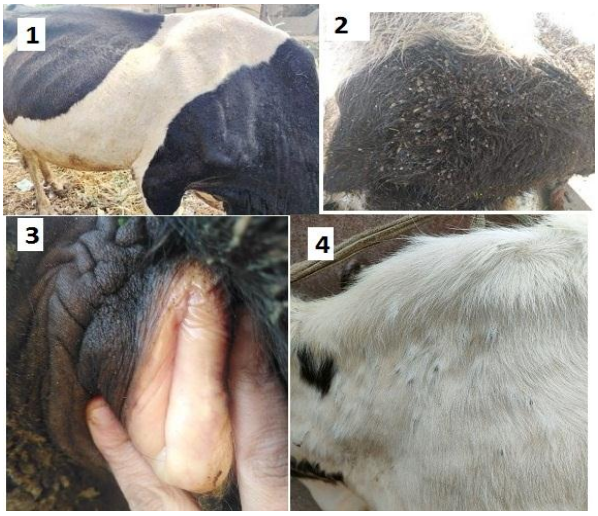

Figure (1)

(1, 2)- Showing presence of engorged female ticks on the body coat of lactating cattle.

(3)- Pale yellowish mucus membrane.

(4)- Engorged female ticks on neck region.

Morphological identification of external parasites

Ticks *Rhipicephalus (Boophilus) annulatus* were identified according to **Estrada-Peña et al., 2004**. Unfed ticks have medium size (3 to 5mm), mouthparts are anterior, female mouth parts with Hypostomal teeth are in 4 + 4 columns, male mouthparts are similar to that of female, palp articles are small, cornua are distinct, basis capituli has distinctly angular lateral margins, coxa 1 spurs length is short, legs have no pale rings, coxa 4 are of normal size, scutum in the female and conscutum in the male have no ornamentation (Figure 2 .A, B).

Figure (2)

A- Dorsal view of adult female Rhipicephalus annulatus (x4), hypostomal teeth are in 4 + 4 columns(x10).

B- Dorsal view of adult male *Rhipicephalus annulatus*(x4), hypostomal teeth are in 4 + 4 columns(x10).

Ticks *(Hyalomma spp.)* were identified according to **Estrada-Peña et al., 2004**. Unfed ticks have large size (5 to 6mm) including mouthparts, female dorsal palp articles 2 are longer than articles 1 and 3, basis capituli has medium angular lateral margins, dark colored scutum with slightly sinuous posterior margin, and legs are long having yellow to pale orange color with indistinct pale patches on the dorsal surface of leg (**Figure** 3).

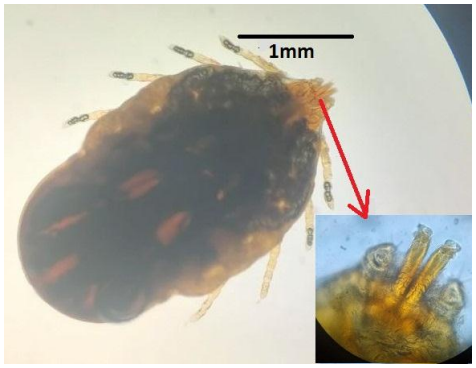

Figure (3)

Dorsal view of female *Hyalomma spp*. (x4), mouth parts (x10).

Blood film finding

Examination of thin blood films revealed that 27 samples were positive for presence of *Babesia spp*. and 30 samples were positive for *Theileria spp.* **(**Figure 4).Prevalence of Ticks, *Babesia spp.* and *Theileria spp*. were shown in (table 1).

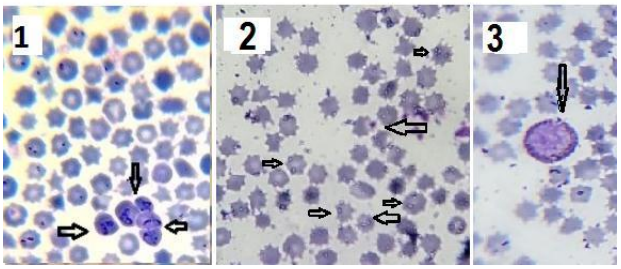

Figure (4)

Thine blood films stained with Giemsa stain showing

1- Pear shape *Babesia bigemina* appear as pairs at obtuse angles to each other.

2- Different shapes of *Theileria spp*. merozoites in RBC.

3-*Theileria spp*. microchizont in lymphocyte

Table(1) Prevalence of Ticks infestation, *Babesia spp.* and *Theileria spp.* infection in dairy cattle.

Parasite found Examined animals	Ticks	*Babesia spp.*	*Theileria spp .*
300 dairy Cows	225	27	30
%	75%	9%	10%

Biochemical analysis of blood

Both calcium and zinc levels were significantly decreased in serum of infested dairy cattle with ticks, infected with *Babesia spp.* and infected with *Theileria spp.* as shown in (Table 2), while

IgE levels showed significant increase especially in cattle infested with ticks (Table 2).

Table (2) The effect of Ticks , *Babesia spp.* and *Theileria spp.* on calcium, zinc and IgE levels in serum of examined dairy cattle.

zinc and IgE levels in serum of examined dairy cattle	Infested with Ticks	Infected with *Babesia spp.*	Infected with *Theileria spp.*	Clinically healthy dairy cattle (n=75)
Ca (mg/dl)	9.3±0.5^{b}	8.7±0.6^{c}	9.2±0.7^{b}	11.3±0.8^{a}
Zn (µg/dl)	0.37±0.001^{b}	0.23±0.001^{c}	0.31±.001^{b}	0.74±0.002^{a}
IgE (µg/ml)	1.7±0.03^{c}	1.1±0.02^{b}	1.2±0.02^{b}	0.95±0.02^{a}

Data are expressed as Means ±SE. Values with different letters (a, b, c) within the same raw are significantly different at *P* value ≤ 0.05.

Most blood parameter including red blood cell (RBC) count , Hemoglobin (Hgb), Hematocrit (HCT**)**, mean cell volume(MCV) and mean corpuscular hemoglobin (MCH) were significantly decreased in serum of infested dairy cattle with ticks, infected with *Babesia spp.* and infected with *Theileria spp.* while mean corpuscular hemoglobin concentration (MCHC) were slightly increased in examined cattle infested with ticks but markedly decreased in examined cattle infected with *Babesia spp.* and infected with *Theileria spp.* as shown in (Table 3).

Table (3) The effect of Ticks , *Babesia spp.* and *Theileria spp.* on blood picture of examined dairy cattle**.**

Blood picture of examined dairy cattle.	Infested with Ticks	Infected with *Babesia spp.*	Infected with *Theileria spp.*	Clinically healthy dairy cattle
RBC (x10^{6}/µl)	4.37±0.03 ^{b}	4.13±0.4 ^{b}	4.21±0.05 ^{b}	6.23±0.5 ^{a}
Hgb(g/dl)	6.1±0.04 ^{b}	5.3±0.7 ^{c}	5.6±0.5 ^{c}	9.8±0.6 ^{a}
HCT(%)	20.2±1.3 ^{b}	18.5±0.9 ^{c}	18.8±1.2 ^{c}	33.2±1.3 ^{a}
MCV (FL)	46.3±1.8 ^{b}	42.9±3.1^{c}	43.8±2.5 ^{c}	53.3±2.8 ^{a}
MCH	13.9±0.3 ^{b}	12.3±0.8 ^{c}	12.8±0.7 ^{c}	15.7±0.7 ^{a}
MCHC (%)	30.0± 1.5 ^{a}	24.8±1.2 ^{b}	25.6±1.2 ^{b}	29.5±1.3 ^{a}

Data are expressed as Means ±SE. Values with different letters (a, b, c) within the same raw are significantly different at *P* value ≤ 0.05.

Chemical analysis of milk

All milk chemical constituents were markedly decreased including calcium and zinc levels leading to decreased milk density of examined dairy cattle. The effect of external and blood parasites on calcium and zinc levels and other chemical constituents were shown in **(Table 4).**

Table (4) The effect of Ticks and blood parasites on chemical milk constituents of examined dairy cattle.

chemical milk constituents of examined dairy cattle	Infested with Ticks	Infected with *Babesia spp.*	Infected with *Theileria spp.*	dairy cattle (Free of any helminth parasites)
Ca (mg/dl)	144.5±13.8 [b]	129±12.3 [c]	132±11.4 [c]	159.4±12.7 [a]
Zn (µ mol/dl)	8.5±0.07 [b]	6.9±0.8 [d]	7.2±0.6 [c]	12.7±0.09 [a]
Fat %	2.16±0.03 [b]	2.3±0.04 [b]	2.13±0.02 [b]	4.47±0.02 [a]
S.N.F%	4.8±0.15 [b]	4.5±0.11 [b]	4.6±0.13 [b]	6.78±0.18 [a]
Lactose %	2.53±0.06 [b]	2.3±0.07 [b]	2.1±0.03 [c]	4.72±0.09 [a]
Salt%	1.71±0.04 [b]	1.54±0.02 [b]	1.6±0.03 [b]	0.55±0.09 [a]
Protein%	2.56±0,10 [b]	2.7±0.02 [b]	2.6±0.09 [b]	3.47±0.22 [a]
Total Solids%	5.65±0.18 [b]	5.3±0.3 [b]	5.4±0.2 [b]	12.25±0.21 [a]
Density	12.96±0.15 [b]	12.6±0.18 [b]	12.7±0.3 [b]	21.94±0.23 [a]
PH	7.26±0.3 [b]	7.21±0.2 [b]	7.23±0.5 [b]	7±0.5 [a]

Data are expressed as Means ±SE. Values with different letters (a, b, c,d) within the same raw are significantly different at *P* value ≤ 0.05.

The reduction of amounts of milk yield of infested dairy cattle with Ticks , infected with *Babesia spp.* and infected with *Theileria spp.* were 46%, 61.2% and 53.8% respectively as shown in **(Table 5)**.

Table (5) The effect of Ticks , *Babesia spp.* and *Theileria spp* .on the produced amount of milk (Kg) in examined dairy cattle.

Produced amount of milk (Kg) in examined dairy cattle	Infested with Ticks	Infected with *Babesia spp.*	Infected with *Theileria spp.*	Clinically healthy dairy cattle
Amount of milk(kg)	7±2 [b]	5±3 [c]	6±3 [d]	13±3 [a]
Reduction %	46%	61.2%	53.8%	---------

Data are expressed as Means ±SE. Values with different letters (a, b, c, d) within the same raw are significantly different at *P* value ≤ 0.05.

DISCUSSION

Many cases were brought to free veterinary medical convoys complaining from decrease of milk yield without any other symptoms except for presence of external parasites which provoked us to study the effect of external parasites on milk production and its components ,our results revealed that 75% of examined dairy cattle were infested with ticks , the same result was recoded by **Fentahun et al., 2023 ,** but this was higher than that reported by **Kakar and Kakarsulemankel 2008** and **Kakar et al., 2017** who recorded (59%). the higher percentage in our research is due the difference of community examined as most cases brought to free veterinary medical convoys were for free eradication of external parasites and internal parasites , also our results showed that 9%of examined dairy cattle were infected with *Babesia spp*. and 10 % were infected with *Theileria spp***.** these results are nearly the same recorded by **Elsify et al., 2015** who reported(10.24%) for *Theileria spp.* and slightly lower than that recorded by **Slim et al., 2022** who reported (16.49%) for *T. annulata* but markedly lower than that recorded by **Fadly 2012** who recorded. (23%) for *Theileria spp.* and (19.33%) for *Babesia* spp. also lower than that reported by **Ritonga et al., 2020** who recorded infection with *Theileria spp.* (33%). The lower incidence of *Babesia spp*. and *Theileria spp.* infection in our study reflects the awareness of owners with the dangerous effects of blood parasites on their cattle that they fallow prophylactic measures to avoid infection, it also reflects the rule of free veterinary medical convoys in that matter .

Calcium levels in blood serum of infested cattle with ticks(9.3±0.5 ml/dl), Infected with *Babesia spp.* (8.7±0.6 ml/dl) and Infected with *Theileria spp.* (9.2±0.7 ml/dl) were significantly decreased than that of Clinically healthy dairy cattle (11.3±0.8ml/dl) and this result agreed with **Mcfadden et al., 2011** and **Abdalsalam et al.,2019** and this may be due to many reasons such as amount intake of calcium or disturbance of thyroid gland as a result of irritation of external parasites **(Moriera et al., 2009) ,** also the levels of zinc blood serum in infested cattle with ticks , Infected with Babesia spp. and Infected with *Theileria spp.* were significantly decreased (0.37±.001, 0.23±0.001 and 0.31±.001µg/dl) which agreed with **Auldist et al., 2007** indicating the association between calcium and zinc, while Ig E in infested cattle with ticks , Infected with Babesia spp. and Infected with Theileria spp. were increased (1.7±0.03, 1.1±0.02 and 1.2±0.02µg/ml) than IgE serum levels of clinically healthy dairy cattle (0.95±0.02µg/ml) that agreed with **Bragaa and Quecchia 2011),** this results may be due to the enhanced permeability by the action of several pro-inflammatory cytokines and induction of immune complex **(DeMeo et al., 2002),** but disagree with **Inokuma et al. (1993)**, also regarding the blood picture analysis of the infested and non infested cattle , we found that most blood parameter which included red blood corpuscles, packed cell volume, hemoglobin percentage were significantly decrease in infested ones with ticks (4.37±0.03 10^6/µl) and markedly decreased in Infected cattle with *Babesia spp.* and to less extend in that Infected with *Theileria spp.* than that of clinically healthy dairy cattle beside the decrease in mean corpuscular, hemoglobin concentration values that agreed with **Sharma et al. , 2016 and Sudhakar Goud et al.,2021**, this may be due to the increased liver enzymes during blood parasites infestation as a result of liver damage leading to elevation of hepatic enzymes, also followed by lysis of RBCs (**Zulfiquar et al., 2012)** due to infection with *Babesia spp*. and to less extend with *Theileria spp.* .The results of calcium levels in milk were significantly decreased in infested cattle with ticks, infected with *Babesia spp.* and infected with *Theileria spp.* (144.5± 13.8mg/dl, 129±12.3 &132±11.4mg/dl) respectively than that of clinically healthy dairy cattle (159.4±12.7 mg/dl) this results was in accord with **Aparna et al., 2011.** The decreasing calcium levels in milk may be due to the decreased calcium levels in blood as the source of milk calcium is mainly from blood calcium, also zinc levels were sharply decreased in milk of infested cattle with Ticks , Infected with *Babesia spp.* and Infected with *Theileria spp.* (8.5±0.7, 6.9±0.8 &7.2±0.6 µmol /L) than the zinc milk levels of clinically healthy dairy cattle (12.7± 0.9µ mol/L) that agreed with **Morton 2004**. All milk constituents and amount of milk yield were markedly changed and decreased, this referred to the decrease of most components that affect milk formation in the alveoli due to the change in osmosis difference inside milk alveoli than outside it which affect their role in milk formation (**Heyman and Desjeux 2000**).

CONCLUSION

There is no doubt that infestation with ticks as a external parasites plus being vector for blood parasites causes sever economic losses not only for the owner but also

for the national income, as our results reveled, severe decrease in milk yield beside the changes in milk component and composition specially the calcium level.

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الملخص العربي

دراسات بيوكيميائية على تأثير الطفيليات الخارجية وطفيليات الدم على إنتاج اللبن ومكوناته في الماشية الحلوب

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الطفيليات الخارجية والداخلية هي السبب الرئيسي للعديد من المشاكل في الأبقار الحلوب. قمنا في هذه الدراسة بالبحث في ارتباط الإصابة بالطفيليات الخارجية وبطفيليات الدم بإنتاج الحليب ومكوناته. تم التعرف على الطفيليات الخارجية وطفيليات الدم في 300 بقرة حلوب وتحديد نسبة الاصابة. تمت دراسة التأثير على المكونات الكيميائية للحليب وبعض العوامل الأخرى بما في ذلك الكمية وتثبيط المناعة. وكانت 75% من الأبقار الحلوب مصابة بالقراد، و9% مصابة بطفيليات الدم من نوع البابيزيا، و10% مصابة بطفيليات الدم من نوع الثيليريا. انخفضت مستويات كل من الكالسيوم والزنك في دماء الأبقار الحلوب المصابة بالقراد،المصابة بالبابيزيا و المصابة بالثيليريا بشكل ملحوظ حيث سجلت(9.3±0.5 ، 8.7 ± 0.6 و 9.2 ± 0.7 ملغم / ديسيلتر) على التوالي بالنسبة للكالسيوم و (0.37 ± 0.001، 0.23 ± 0.001 و 0.31 ± 001 ميكروغرام / ديسيلتر) على التوالي بالنسبة للزنك.كما سجلت مستويات الأرجين ((IgE زيادة بشكل ملحوظ (1.7 ± 0.03 ميكرو / مل) في دماء الابقار المصابة بالقراد ، (1.1±0.02 ميكرو / مل) في دماء الابقار المصابة بالقراد و (1.2±0.02 ميكرو / مل) عنها في دماء الابقار الغير المصابة كما انخفض بشكل ملحوظ مستوى الكالسيوم في حليب الأبقار الحلوب المصابة بالقراد(144.5 ± 13.8 ملجم / ديسيلتر) المصابة بالبابيزيا (129 ± 12.3 ملجم / ديسيلتر) والمصابة بالثايليريا(132 ± 11.4 ملجم / ديسيلتر (مقارنة بالابقار الغير مصابة (159.4 ± 12.7 ملجم / ديسيلتر).). كما سجلت مستويات الزنك في الحليب قيماً متناقصة في الأبقار المصابة بالقراد ، المصابة بالبابيزيا و المصابة بالثايليريا (8.5±0.07، 6.9±0.8 و7.2±0.6 ميكرومول /ديسيلتر) مقارنة بالغير مصابة (12.7±0.09 ميكرومول /ديسيلتر).