Original Research Article

Effect of Sarcoptic Mange on Haemato-biochemical Parameters

ABSTRACT

Aims: The present study was conducted to observe the effect of *Sarcoptic scabiei* infection on various haematological and biochemical parametersin dogs and to investigate the effect of 2% combination of three essential oils, i.e. 1% Lemongrass oil (*Cymbopogoncitratus*), 0.5% Tulsi oil (*Ocimumtenuiflorum*) and 0.5% Sandalwood oil (*Santalum album*) in ameliorating these parameters.

Study design: The clinically affecteddogs that were brought to the Veterinary Clinical Complex with symptoms of sarcoptic mange were included in the study. Haemato-biochemical parameters of dogs found positive were analyzed and compared to the healthy ones to identify any significant difference caused by *Sarcoptesscabiei.* Furthermore, efficacy of topical application of the 2% essential oil combination was compared with Ivermectin.

Place and Duration of Study: The study was conducted at Department of Veterinary Medicine and Veterinary Clinical Complex, DUVASU, Mathura, India, over a span of 18 months, from February, 2023 to July, 2024.

Methodology: Total 123 dogs were included in the present study, out of which 31 dogs were found positive with *S. scabiei* on the basis of clinical and microscopic examination of skin scrapings. These positive dogs were subjected to study the changes in various haemato-biochemical parameters. Further,twelve of these positive dogs were divided into two groups, one treated with the 2% essential oil combination topically, and the other with Ivermectin injection, given subcutaneously. Six apparently healthy dogs were treated as control. These haemato-biochemical parameters were estimated at days 0 (pre-therapy), and days 14 and 28 (post-therapy). Student's t-test and Analysis of Variance (ANOVA) in Graphpad Prism software was used for statistical analysis.

Results: Dogs with sarcoptic mange exhibited significantly lower levels of TEC, Hb, HCT, MCH, MCHC, total protein and albumin while significantly higher levels of TLC, neutrophils, ALT, AST and ALP enzymes was noted. Both the treatment groups were successful in amelioration of these haemato-biochemical parameters post-therapy.

Conclusion: The essential oils can be used as an alternative therapy option in managing sarcoptic mange.

Keywords: Sarcoptesscabiei; haematology; biochemical study; essential oils.

1. Introduction

Sarcoptesscabiei, the burrowing parasite causing sarcoptic mange, affects numerous domestic and wildlife species (Escobar et al., 2022). The mite resides in the skin's epidermis, feeding on lymph and sloughed epithelial cells (El-Spiey et al., 2016).It exhibits a near-global distribution,

facilitated by various forms of transmission and its ability to utilize a diverse range of host species**.**Scabies gained recognition as a neglected tropical disease by the World Health Organization in 2017 (Andriantsoanirina et al., 2022).Typically, lesions manifest on the head, pinnae, legs (especially the elbows and hocks), and ventrum (Pin et al., 2006). The feeding activity of *Sarcoptes* induces intense itching and scratching due to marked irritation, leading to self-inflicted lesions that exacerbate the condition. This causes wound formation, erythematous skin, development of papules and vesicles, and ultimately triggers an inflammatory reaction, culminating in the formation of exudate. The exudate settles on the skin surface, resulting in the formation of crusts, skin thickening, and eventual hair loss (Lastuti et al., 2018).

The diagnosis of scabies poses significant challenges, as mites are detected in only 20–50% of skin scrapings from infested dogs (Lower et al., 2001). Initial infections involve a minimal number of mites, and symptoms may not manifest for several weeks [39]. Presumptive diagnosis can be based on clinical symptoms, but a definitive diagnosis relies on the microscopic identification of mites, eggs, and/or fecal pellets, as well as burrows in the epidermis, obtained through skin scraping with a scalpel (Arlian and Morgan, 2017).

The treatment of sarcoptic mange using various acaricides such as diazinon, deltamethrin, permethrin, and ivermectin has achieved varying degrees of success [40]. However, the increasing concern is the risk of emergence of mite resistance (Bernigaud et al., 2018). These insecticides can potentially pollute the environment around animals and have various hazards and side effects. Therefore,the present study was undertaken to understand the clinico-haemato-biochemical alterations in dogs suffering from sarcoptic mange and its management using three essential oils combination comprising *Cymbopogoncitratus* (Lemongrass), *Santalum album* (sandalwood) and *Ocimumtenuiflorum*(Tulsi).

2. Materials and Methods

The clinical cases of dogs brought to the Veterinary Clinical Complex (VCC), Kothari Hospital, DUVASU, Mathura, over a period of 18 months (February, 2023 to July, 2024) were included for the study. During this period, 123 dogs were suspected of having sarcoptic mange, out of which 31 dogs were found positive. Clinical diagnosis was based on the microscopic examination for *Sarcoptesscabiei* mites or their developmental stages in the skin scrapings collected using method described by Upadhyay et al. (2019). The clinical and haemato-biochemical changes associated with canine sarcoptic mange were recorded.

Essential oils combination (2%) comprising of 1% Lemongrass oil, 0.5% Tulsi oil and 0.5% Sandalwood oil was tested against *Sarcoptes* infected dogs.Group 1 comprised of 6 apparently healthy dogs, of any age, breed and sex. Group 2 had six infected dogs that were treated topically with the 2% EO combination, once a week, till 4 weeks, while group 3 had six infected dogs that were treated with Inj. Ivermectin @ 0.2 mg/kg b.wt. SC every week for 4 treatments.

Haematological parameters like Total erythrocyte count (TEC), Total leukocyte count (TLC), Differential leukocyte count (DLC), Haematocrit (HCT), Hemoglobin (Hb), Mean corpuscular

hemoglobin (MCH), Mean corpuscular volume (MCV) and Mean corpuscular hemoglobin concentration (MCHC) were estimatedusing fully automated hematologyanalyzerand biochemical parameters studied in the serum samples wereAspartate Aminotransferase (AST), Alanine Aminotransferase (ALT), Alkaline Phosphatase (ALP), Blood Urea Nitrogen (BUN), Creatinine (mg/dL), Total protein (TP) and Albumin (Alb), performed using autochemingeniiousanalyzer using diagnostic kits. Globulin (Glb) was calculated by subtracting albumin from total protein.These estimations were doneat days 0 (pre-treatment) and days 14 and 28 (post-treatment).

The values of various parameters were expressed as mean ± S.E. and data were analyzed for any significant variation by t-test and Analysis of Variance (ANOVA) using Graphpad Prism software. The level of statistical significance for all comparisons was established at (P= 0.05).

3. Results and Discussion

3.1 Clinical Findings

During the clinical examination for sarcoptic mange, most of the dogs screened exhibited symptoms such as pruritus, crusting, alopecia, erythema, irritability, papules, and excoriations. Intense itching and self-inflicted trauma from scratching were observed in all the dogs. The primary areas affected were the ear margins, legs (especially the elbows and hocks), face, and ventral region. All the dogs showed a markedly positive pinnal-pedal scratch reflex on day 0. Similar findings were observed by Feather et al. (2010), Reddy et al. (2014), Upadhyay et al. (2019), Arul et al. (2023) and Meshram et al. (2014). These symptoms are likely caused by hypersensitivity to the secretions, excretions, and proteins in the faecal matter of *Sarcoptes* mites as they burrow through the epidermis (Lodh et al., 2012; Reddy et al., 2014; Upadhyay et al., 2019). These secretions and excretions of the mites can cause irritation and allergic reactions, leading to intense itching, a hallmark of scabies (Upadhyay, 2019).

Alopecia occurs due to both follicle damage caused by the mites and secondary effects of intense itching (Upadhyay, 2019). The adverse effects on skin, such as erythema, edema, wrinkling, inflammation, autoimmune reactions, hypersensitivity, and keratinization are attributed to free radicals and oxidative stress (Behera et al., 2011). Proliferation of mast cells and resultant increase in chymase and tryptase activity is supposed to play an important role in development of skin lesions (Beigh et al., 2016).

According to previous studies, the pinnal-pedal reflex test successfully identified 93.8% of sarcoptic mange cases (Mueller et al., 2001). Bourdeau et al. (2004) similarly reported that 75% to 90% of dogs with sarcoptic mange display a positive pinnal-pedal reflex (Griffin, 1993; Mueller et al., 2001) and Scott et al. (2013), observed this reflex to be positive in 78.4% of the dogs with confirmed and presumed scabies. Almost all dogs with a positive pinnal-pedal reflex test were found to have canine scabies, making this test useful for an initial diagnosis. For more accurate confirmation, microscopic examination of skin scrapings after KOH treatment (Kumari, 2022) or PCR-based molecular method can be employed.

3.2 Haematological Analysis

The haematological alterations of dogs with sarcoptic mange (N=31) and healthy controls (N=06) are depicted in Table 1. Comparing sarcoptic mange-affected dogs to healthy dogs, significant changes in the hemogram panels were seen. Dogs with sarcoptic mange exhibited significantly lower levels of TEC, Hb, HCT, and MCH and MCHC. Additionally, the MCV value of infected dogs were significantly increased. These findings are in accordance with those of Sakina and Mandial (2013), Allam et al. (2014), Behera et al. (2011), Beigh et al. (2016), De and Dey (2010), Katariya et al. (2018), Lodh et al. (2012), Meshram et al. (2014), Nwufoh et al., 2019, Reddy et al (2014), Sivakumar et al. (2017) and Upadhyay et al. (2019). Significantly higher total leukocyte counts and neutrophil counts, while a significantly lower monocyte and lymphocyte count, were observed as compared to healthy dogs (Table 2). However, no significant change was found in the eosinophil count.

Table 1: Comparison of hemogram of dogs with sarcoptic mange (N=31) and healthy controls (N=06)

Parameters	Healthy Dogs (06)	Infected dogs (N=31)	P- value
TEC ($\times 10^6$/µL)	6.46 ± 0.34	5.72 ± 0.36	<0.0001
Hb (g/dL)	13.85 ± 0.86	11.23 ± 0.58	<0.0001
HCT (%)	43.13 ± 2.41	38.46 ± 2.51	0.0002
MCV (fL)	67.11 ± 1.36	69.39 ± 1.48	0.0013
MCH (pg)	22.60 ± 0.46	20.35 ± 1.37	0.0166
MCHC (g/dL)	33.47 ± 0.51	29.67 ± 1.47	<0.0001

Data presented are Mean ± S.E.M.

Differed significantly ($p \leq 0.05$), when compared with healthy animals

Table 2: Comparison of leukogram of dogs with sarcoptic mange (N=31) and healthy controls (N=06)

Parameters	Healthy Dogs (06)	Infected dogs (N=31)	P- value
TLC ($\times 10^3$/µL)	12.59 ± 1.39	19.10 ± 1.58	<0.0001
Neutrophil (%)	70.25 ± 1.94	79.02 ± 1.76	<0.0001
Eosinophil (%)	0.61 ± 0.33	0.49 ± 0.30	0.3956
Monocyte (%)	4.72 ± 0.54	3.28 ± 0.63	<0.0001
Lymphocyte (%)	24.42 ± 1.66	17.20 ± 1.47	<0.0001

Data presented are Mean ± S.E.M.

Differed significantly ($p \leq 0.05$), when compared with healthy animals

3.3 Biochemical Analysis

The estimated serum biochemical panels of dogs with sarcoptic mange were compared to those of healthy controls on the day of presentation. Dogs with sarcoptic mange had significantly higher levels of ALP, ALT andAST, whereas the total protein and albumin concentration were significantly lower. No appreciable differences in the other investigated biochemical panels were observed (Table 3). Similar findings have been reported by Sakina and Mandial (2013), Behera et al. (2011), De and Dey (2010), Reddy et al. (2014) and Upadhyay et al. (2019). However, Nwufoh et al. (2019) found no abnormalities in ALT and AST levels in *Sarcoptes*-infected dogs and concluded that

liver function might not be linked to scabies infestation. Additionally, Beigh et al. (2016) and Sakina and Mandial (2013) observed hyperglobulinemia in dogs with sarcoptic mange.

Table 3: Comparison of serum biochemical panels of dogs with sarcoptic mange (N=31) and healthy controls (N=06)

Parameters	Healthy (N=06)	Infected dogs (N=31)	P-value
Alanine Aminotransferase ALT (U/L)	26.66 ± 4.99	41.38 ± 2.55	<0.0001
Aspartate Aminotransferase (U/L)	21.42 ± 2.46	31.01 ± 2.89	<0.0001
Alkaline Phosphatase ALP (U/L)	72.34 ± 5.57	119.57 ± 9.90	<0.0001
Blood Urea Nitrogen BUN (mg/dL)	13.09 ± 1.01	15.22 ± 1.59	0.0035
Creatinine (mg/dL)	0.68 ± 0.15	0.86 ± 0.21	0.0497
Total Protein (g/dL)	6.65 ± 0.47	5.83 ± 0.34	<0.0001
Albumin (g/dL)	3.26 ± 0.12	2.62 ± 0.27	<0.0001
Globulin (g/dL)	3.39 ± 0.45	3.22 ± 0.27	0.2066

Data presented are Mean ± S.E.M.

Differed significantly ($p \leq 0.05$), when compared with healthy animals

3.4 Efficacy of Essential Oils

The Mean ± SE values of various haemato-biochemical parameters in different groups at days 0(pre-treatment) and days 14 and 28 (post-treatment) are illustrated in the Table 4and Figures 1-19.

Table 4: Haemato-biochemical parameters of dogs under study at days 0, 14 and 28

Parameter	Groups	Day 0	Day 14	Day 28
TEC (×10^6/µL)	1 (Healthy)	6.46 ± 0.34^{a}	6.46 ± 0.34^{a}	6.46 ± 0.34
	2 (EO treated)	5.65 ± 0.41^{Bb}	5.76 ± 0.41^{Bb}	6.05 ± 0.30^{AB}
	3 (IVM control)	5.93 ± 0.44^{b}	5.94 ± 0.44^{b}	6.11 ± 0.38
Hb (g/dl)	1 (Healthy)	13.85 ± 0.86^{a}	13.85 ± 0.86^{a}	13.85 ± 0.86^{a}
	2 (EO treated)	11.12 ± 0.60^{Cb}	11.53 ± 0.65^{BCb}	12.50 ± 0.42^{ABb}
	3 (IVM control)	11.49 ± 0.80^{Bb}	12.05 ± 0.55^{Bb}	13.33 ± 0.46^{Ab}
HCT (%)	1 (Healthy)	43.13 ± 2.41^{a}	43.13 ± 2.41^{a}	43.13 ± 2.41
	2 (EO treated)	38.93 ± 2.35^{b}	39.12 ± 1.88^{b}	40.44 ± 1.18
	3 (IVM control)	39.75 ± 3.10^{b}	40.35 ± 1.77^{b}	42.69 ± 1.47
MCV (fL)	1 (Healthy)	67.11 ± 1.36	67.11 ± 1.36	67.11 ± 1.36
	2 (EO treated)	69.20 ± 1.32	69.32 ± 1.17	68.56 ± 2.43
	3 (IVM control)	68.77 ± 1.44	67.45 ± 2.16	68.34 ± 1.88
MCH (pg)	1 (Healthy)	22.60 ± 0.46^{a}	22.60 ± 0.46^{a}	22.60 ± 0.46

	2 (EO treated)	20.73 ± 1.83^{ABb}	20.85 ± 1.02^{Bb}	21.36 ± 0.95^{AB}
	3 (IVM control)	20.65 ± 1.05^{Bb}	21.26 ± 1.59^{ABb}	21.73 ± 1.25^{AB}
MCHC (g/dL)	1 (Healthy)	33.47 ± 0.51^{a}	33.47 ± 0.51^{a}	33.47 ± 0.51
	2 (EO treated)	30.38 ± 1.59^{Bb}	32.08 ± 1.00^{ABb}	32.30 ± 1.25^{AB}
	3 (IVM control)	29.08 ± 1.77^{Bb}	30.13 ± 2.07^{Bb}	33.85 ± 1.03^{A}
TLC (×10^3/µL)	1 (Healthy)	12.59 ± 1.39^{b}	12.59 ± 1.39^{b}	12.59 ± 1.39^{b}
	2 (EO treated)	18.18 ± 1.88^{a}	17.23 ± 1.86^{a}	15.54 ± 1.42^{a}
	3 (IVM control)	19.03 ± 1.44^{Aa}	16.46 ± 1.45^{Aa}	13.63 ± 1.19^{Ba}
Neutrophil (%)	1 (Healthy)	70.25 ± 1.94^{b}	70.25 ± 1.94^{b}	70.25 ± 1.94
	2 (EO treated)	78.43 ± 1.67^{Aa}	75.37 ± 0.96^{Ba}	69.74 ± 2.56^{C}
	3 (IVM control)	79.32 ± 1.67^{Aa}	76.31 ± 1.67^{Ba}	73.71 ± 1.56^{B}
Eosinophil (%)	1 (Healthy)	0.61 ± 0.33	0.61 ± 0.33	0.61 ± 0.33
	2 (EO treated)	0.74 ± 0.18^{B}	0.78 ± 0.28^{AB}	1.19 ± 0.20^{A}
	3 (IVM control)	0.51 ± 0.46	0.54 ± 0.30	0.73 ± 0.18
Monocyte (%)	1 (Healthy)	4.72 ± 0.54^{a}	4.72 ± 0.54^{a}	4.72 ± 0.54^{a}
	2 (EO treated)	3.27 ± 0.51^{b}	3.12 ± 0.61^{b}	3.38 ± 0.33^{b}
	3 (IVM control)	3.23 ± 0.66^{b}	3.52 ± 0.40^{b}	3.32 ± 0.37^{b}
Lymphocyte (%)	1 (Healthy)	24.42 ± 1.66^{a}	24.42 ± 1.66^{a}	24.42 ± 1.66
	2 (EO treated)	17.56 ± 1.43^{Cb}	20.73 ± 0.71^{Bb}	25.69 ± 2.36^{A}
	3 (IVM control)	16.94 ± 1.09^{Cb}	19.63 ± 1.40^{Bb}	22.24 ± 1.38^{A}
ALT (U/L)	1 (Healthy)	26.66 ± 5.10^{c}	26.66 ± 5.10^{c}	26.66 ± 5.10^{c}
	2 (EO treated)	40.56 ± 3.17^{Ab}	38.45 ± 2.46^{Ab}	33.71 ± 2.22^{Bb}
	3 (IVM control)	43.04 ± 2.89^{a}	43.39 ± 2.07^{a}	45.43 ± 2.01^{a}
AST (U/L)	1 (Healthy)	21.42 ± 2.46^{b}	21.42 ± 2.46^{b}	21.42 ± 2.46^{b}
	2 (EO treated)	31.44 ± 2.92^{a}	34.36 ± 2.96^{a}	33.19 ± 1.01^{a}
	3 (IVM control)	31.39 ± 2.27^{a}	30.72 ± 2.20^{a}	33.52 ± 1.74^{a}
ALP (U/L)	1 (Healthy)	72.34 ± 5.57^{c}	72.34 ± 5.57^{c}	72.34 ± 5.57^{c}
	2 (EO treated)	117.03 ± 11.83^{b}	101.59 ± 9.07^{b}	103.51 ± 4.90^{b}
	3 (IVM control)	118.52 ± 13.45^{a}	120.31 ± 10.96^{a}	124.82 ± 8.66^{a}
BUN (mg/dl)	1 (Healthy)	15.93 ± 1.63	15.93 ± 1.63	15.93 ± 1.63
	2 (EO treated)	12.66 ± 1.42^{B}	15.26 ± 2.17^{AB}	18.45 ± 2.95^{A}
	3 (IVM control)	12.45 ± 1.58^{B}	15.11 ± 3.16^{AB}	18.10 ± 2.27^{A}
Creatinine (mg/dl)	1 (Healthy)	0.68 ± 0.15^{B}	0.68 ± 0.15^{B}	0.68 ± 0.15^{Bb}
	2 (EO treated)	0.73 ± 0.13	0.72 ± 0.07	0.97 ± 0.18^{a}
	3 (IVM control)	0.71 ± 0.11^{B}	0.77 ± 0.14^{AB}	1.01 ± 0.16^{Aa}
Total Protein (g/dl)	1 (Healthy)	6.65 ± 0.47^{a}	6.65 ± 0.47^{a}	6.65 ± 0.47^{a}
	2 (EO treated)	5.67 ± 0.13^{Bb}	5.71 ± 0.07^{Bb}	5.94 ± 0.21^{ABb}
	3 (IVM control)	5.85 ± 0.35^{Bb}	5.78 ± 0.24^{Bb}	6.10 ± 0.30^{ABb}
Albumin (g/dl)	1 (Healthy)	3.26 ± 0.12^{a}	3.26 ± 0.12^{a}	3.26 ± 0.12^{a}

	2 (EO treated)	2.49 ± 0.26^{b}	2.63 ± 0.17^{b}	2.81 ± 0.09^{b}
	3 (IVM control)	2.62 ± 0.23^{b}	2.66 ± 0.18^{b}	2.74 ± 0.17^{b}
Globulin (g/dl)	1 (Healthy)	3.39 ± 0.45	3.39 ± 0.45	3.39 ± 0.45
	2 (EO treated)	3.18 ± 0.29	3.09 ± 0.20	3.14 ± 0.20
	3 (IVM control)	3.23 ± 0.19	3.12 ± 0.11	3.36 ± 0.25

Mean with different superscript (a, b, c, d) in rows are differing significantly in between the groups, otherwise non-significant.

Mean with different superscript (A, B, C, D) in columns are differing significantly in between the intervals, otherwise non-significant.

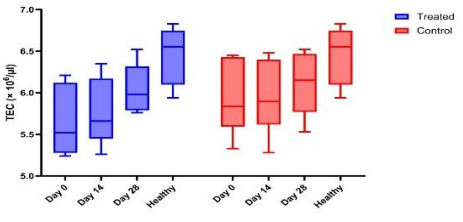


Fig 1: TEC levels in treatment groups on days 0, 14 and 28

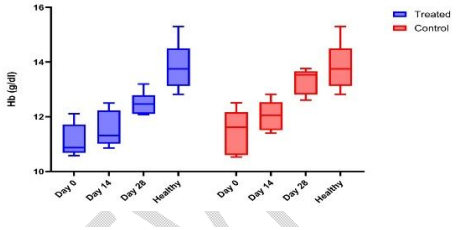


Fig 2: Hb levels in treatment groups on days 0, 14 and 28

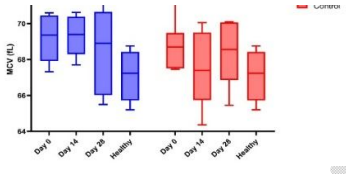


Fig 3: Haematocrit levels in treatment groups on days 0, 14 and 28

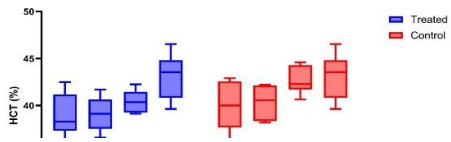


Fig 4: MCV levels in treatment groups on days 0, 14 and 28

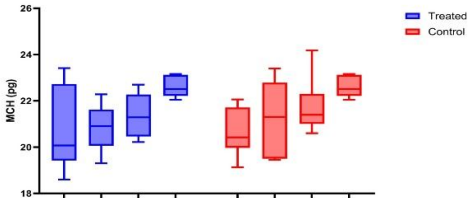


Fig 5: MCH levels in treatment groups on days 0, 14 and 28

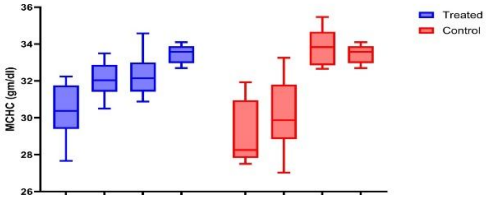
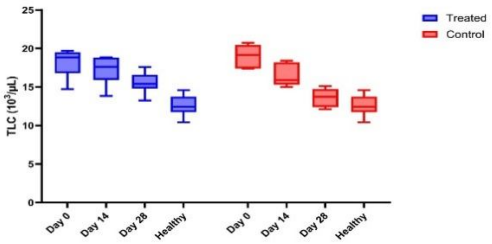


Fig 6: MCHC levels in treatment groups on days 0, 14 and 28



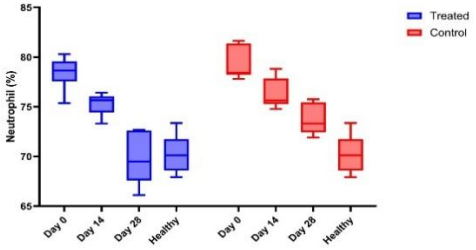


Fig 8: Neutrophil (%) in treatment

Fig 7: TLC levels in treatment groups on days 0, 14 and 28

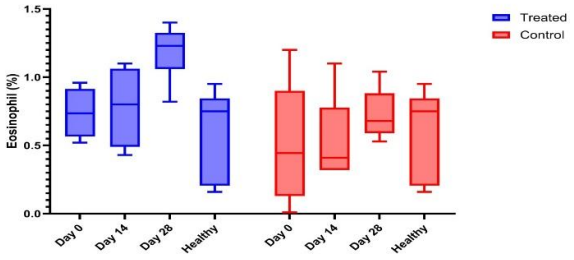


Fig 9: Eosinophil (%) in treatment groups on days 0, 14 and 28

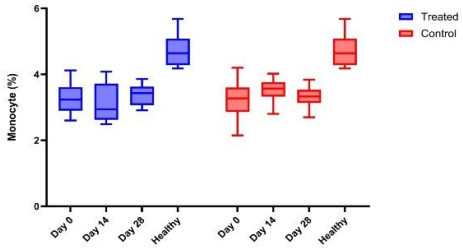


Fig 10: Monocyte (%) in treatment groups on days 0, 14 and 28

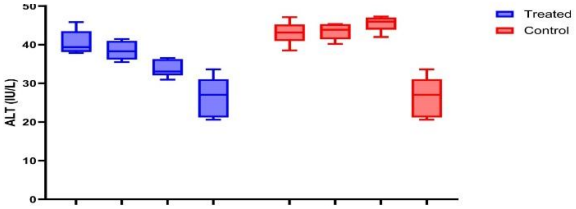


Fig 11: Lymphocyte (%) in treatment groups on days 0, 14 and 28

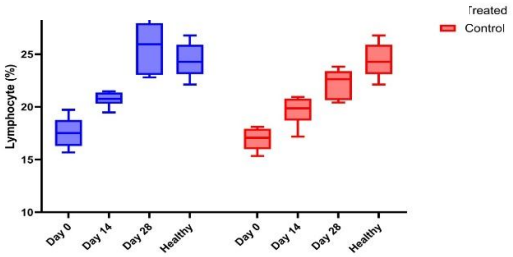


Fig 12: ALT levels in treatment groups on days 0, 14 and 28

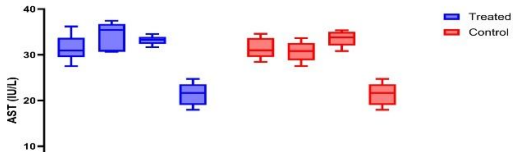


Fig 13: AST levels in treatment groups on days 0, 14 and 28

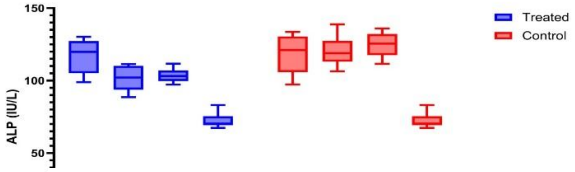


Fig 14: ALP levels in treatment groups on days 0, 14 and 28

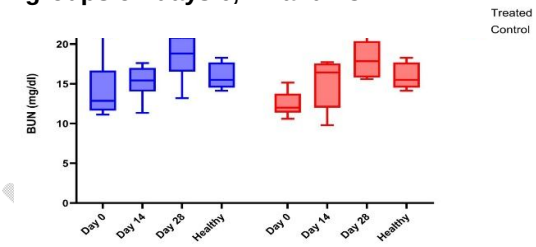


Fig 15: BUN levels in treatment groups on days 0, 14 and 28

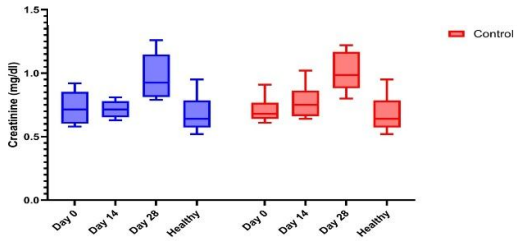
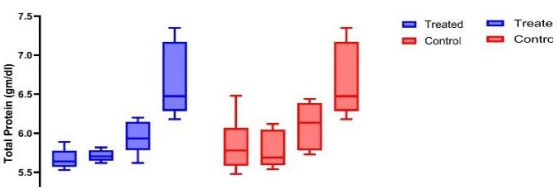


Fig 16: Creatinine levels in treatment groups on days 0, 14 and 28



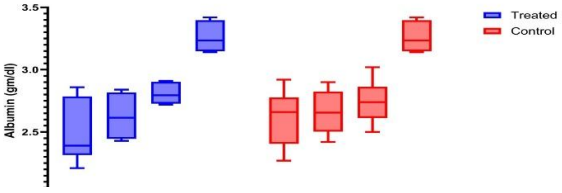


Fig 17: Total protein levels in treatment groups on days 0, 14 and 28

Fig 18: Albumin levels in treatment groups on days 0, 14 and 28

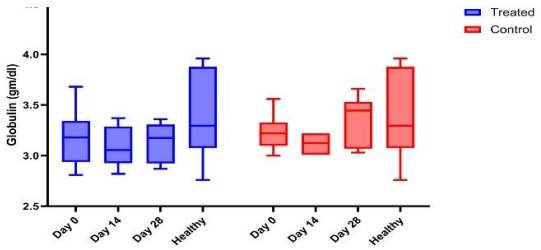


Fig 19: Globulin levels in treatment groups on days 0, 14 and 28

The haematological changes may result from the mites' blood-feeding behaviour (Nwufoh et al., 2019) or the suppression of erythropoiesis due to toxic substances secreted by the mites (Allam et al., 2014). Additionally, these changes could be attributed to restlessness, reduced appetite, blood loss from scratching, and oxidative damage to erythrocytes, which can lead to membrane injury, osmotic fragility and destruction of the cells (Beigh et al., 2013).Upadhyay et al. (2019) observed a significant reduction in MCH, MCHC and significant elevation in MCV in dogs with sarcoptic acariasis, as compared to the healthy ones. The increase in MCV may be due to the insufficient supply of maturation factors required for erythrocyte development, likely caused by the inappetence associated with the disease. Reduction in MCH and MCHC could result from the chronic and widespread nature of the disease or prolonged inappetence due to the pruritogenic nature of mites.

Dogs with sarcoptic mange exhibited significantly higher total leukocyte counts and neutrophil counts, while a significantly lower monocyte and lymphocyte count. Sakina and Mandial (2013) observed similar alterations in canine scabies with leucocytosis, neutrophilia and lymphopenia. The leukocytosis observed in severely infested dogs, along with neutrophilia and lymphopenia, may be due to secondary bacterial infections caused by continuous itching (De and Dey, 2010). Neutrophilia may be due to the activation of the body's defense mechanisms to fight the infection (Katariya et al., 2018). Leukocytosis can also be attributed to the body's cellular and humoral immune responses, in response to the tissue damage or necrosis caused by inflammation (Lodh et al., 2012).

Infected dogs exhibit reduction in feed intake, along with decreased feed digestibility, impaired nutrient absorption and alteration in hepatic structure and function (Allam et al., 2014). Many workers have reported amyloidosis in the liver and lesions in other vital organs, including the skin, during histopathological examinations of severe scabies infections in rabbits and wild animals (Beigh et al., 2016). Elevated levels of ALT, AST and bilirubin along with reduced levels of albumin suggest compromised liver functions in dogs with severe scabies infections. Cause of liver dysfunction may be the harmful effects of pro-inflammatory cytokines and/or toxins secreted by mites, which negatively impact vital organs (Beigh et al., 2016).

Altered value of various biochemical indicators have also been reported in cases of severe mite infection in calves (De and Dey, 2010). Sinha et al. (2004) observed increase in ALT levels during mite infestation in pigs, indicating increased activity of liver and other vital organs as they work to neutralize toxic materials. During infestation, the *S. scabiei* mite burrows in the skin's stratum corneum and remains there throughout its entire life cycle. As the infestation progresses, the number of mites in the skin increases, releasing substantial amounts of antigenic material from their saliva, faecal pellets (scybala), and other secretions. *S. scabiei* serine protease paralogs, which are key antigens, have been found both inside the mite's gut and in its faeces. Researchers have discovered that *in vivo* and *in vitro* exposure to *S. scabiei* antigens can elevate pro-inflammatory cytokine levels in the blood and skin cells (De and Dey, 2010).

Decrease in serum total protein and albumin levels may be attributed to the loss of plasma proteins due to exudative dermatitis and the constant fluid consumption by mites (Nwufoh et al., 2019; Onoja et al., 2016). Other possible factors include protein oxidation, lipid peroxidation, and DNA damage caused by free radicals. The lower albumin level likely would have contributed to the overall reduction in total protein (Behera et al., 2011; Lodh et al., 2012). The decline in albumin levels could also result from increased protein catabolism triggered by stress from ectoparasite infestations (Katariya et al., 2018). Rathore et al. (2024) stated that the lower serum total protein, albumin and globulin levels in cattle with mite infestations might be due to poor nutritional status, as a consequence of reduced feed intake and anorexia in diseased animals.

According to Upadhyay et al. (2019), the burrowing activity of mites leads to the leaching of protein fractions from body fluids, resulting in hypoproteinemic condition. Continuous loss of plasma proteins due to internal bleeding, along with subsequent hemodilution from fluid mobilization caused by pruritus, may also lead to hypoalbuminemia. Allaam et al. reported significantly low urea and creatinine levels in Egyptian Buffaloes (Bubalus bubalis) infested with sarcoptic mange, attributing the drop in urea to a loss of appetite.

The hemogram and leukogram of dogs infected with *Sarcoptes* showed remarkable improvement by day 28 post-therapy in both treatment groups.In the essential oil treatment group (2% EO combination) there was a significant increase in total erythrocyte count (TEC), hemoglobin, mean corpuscular hemoglobin concentration (MCHC), and lymphocyte percentage. A non-significant rise in haematocrit and mean corpuscular hemoglobin (MCH) was also observed. Additionally, the EO treatment group showed a significant decrease in neutrophil percentage and a non-significant reduction in total leukocyte count (TLC). In contrast, the ivermectin-treated group displayed a significant decrease in both TLC and neutrophil percentage. In the biochemical panel, the essential oil (EO) treated group showed a significant reduction in alanine aminotransferase (ALT), a non-significant reduction in alkaline phosphatase (ALP), a significant increase in total protein, and a non-significant rise in albumin levels by day 28 post-treatment. In contrast, the ivermectin-treated group exhibited a non-significant increase in both ALT and ALP enzyme levels.

According to Kebede and Negese (2017), the essential oil of *Cymbopogoncitratus* demonstrated efficacy comparable to reference drugs (diazinon and ivermectin) at concentrations of

1.25-2.5% against *Sarcoptesscabiei* var. caprae, achieving 100% recovery in goats at a concentration of 0.625%.Magdaş et al. (2010) observed that oil of sweet basil (*Ocimumbasilicum*) was effective against the poultry red mite *Dermanyssusgallinae,in vitro* using a direct contact method at a dosage of 0.6 mg/cm^2.According to Raina et al. (2013), *O. tenuiflorum* essential oilwas suggested to possess strong antimicrobial, insecticidal, antihelmenthic, nematicidal, antioxidant, myorelaxant, stimulant and anaesthetic properties. Many researchers have demonstrated sandalwood essential oil to have antiscabietic and antiseptic properties (Boruah et al., 2023), anti-inflammatory and antimicrobial potency (Moy and Levenson, 2017).

4. Conclusion

The most commonly used tools for making health decisions are haemato-biochemical panels (Klinkon and Ježek, 2012). A complete blood count (CBC) provides valuable information for diagnosing diseases, monitoring a patient's health, and predicting their prognosis (Roland et al., 2014). Canine scabies,being a highly pruritic, transmissible canine dermatosis, is caused by infestation with mite *Sarcoptesscabiei*v*arcanis*. It spreads through close contact between infested dogs or by contaminated fomites and produces alterations in various haemato-biochemical panels (Upadhyay et al., 2019).

Achieving a complete clinical and parasitological cure for mite-induced dermatitis takes a very long time, often requiring the repeated and frequent use of allopathic miticides (Kumari, 2022). Prolonged and frequent use of these drugs can lead to the accumulation of drug residues, which pose environmental risks and increase the potential for drug resistance in target species (Currie et al., 2004).

Based on the findings of this study, the essential oil treatment group showed comparable effectiveness to the ivermectin-treated group in improving the altered haematological and biochemical profiles. By day 28 post-therapy, some treated dogs still exhibited mild pruritus and a pinnal-pedal reflex, though both were significantly less severe compared to day 0. These dogs were monitored for an additional month beyond the trial period, during which no pinnal-pedal reflex or signs of pruritus were observed, indicating full clinical recovery.These findings highlight the potential of essential oils as alternative therapies or as adjunct treatments alongside traditional miticides for managing canine sarcoptic mange.

ETHICAL APPROVAL

The blood was collected from the diseased dogs and healthy animals under the ethical standards and guidelines of the Institutional Animal Ethics Committee (IAEC) and due permission was received from the ethical committee of the University via voucher no. IAEC/22/2/14 dated 28-12-2022.

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2.
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