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Epizoology of Ixodid tick infestations in cattle in and around BBAU campus, Lucknow

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Abstract
India ranks as the topmost milk-producing country in the world. It's 'raining milk' in Uttar Pradesh, the *Uttam* Pradesh of the country. Both India and the state of the U.P. have the second-highest cattle population at their respective levels. The purest and the most sacred animal in Hindu mythology- 'cow' (*Bos spp.*) has been a symbol of non-violent generosity as her products like milk provide nourishment from an infant to a fully grown adult. Cattle rearing faces several health issues of rearing animals mainly due to parasitism. The ectoparasites of cow, ticks harm the animal by attaching their mouthparts to animal skin and feeding exclusively on the host's blood and body fluids. Ixodid tick infestations cause many threats to the cattle and thus making the animal more vulnerable to several ailments. The proposed study is designed to perform the Epizoology explaining the Morphology, Biodiversity, and Prevalence of Ixodid ticks infesting the cattle in and around BBAU campus, Lucknow, Uttar Pradesh. The estimated value of the Shannon diversity index was observed to be -1.1. During the study, 135 cattle were surveyed, of which 79 cattle were found to be pestered with ticks. The altogether occurrence was computed as equal to 58.51% and 103 ticks were gathered from the cattle's bodies, the majority were males. The collected Ixodid ticks of four species were recognized as *Rhipicephalus (Boophilus) microplus* (56.31%), *Haemaphysalis bispinosa* (16.50%), *R. sanguineus* (4., 85%), and *Hyalomma anatolicum* (22.34%). The prevalence of Ixodid ticks was studied and analyzed concerning the months of the study, management practices, breed, sex, age, and sites of predilection on cattle.

Keywords: Ixodid ticks; cattle; epizoology; parasitism; light microscopy; scanning electron microscopy (SEM); shannon diversity index; prevalence

Introduction
Epizoology (from Greek: epi=upon, among + zoon=animal + logos=study, discourse), epizootiology, or veterinary epidemiology is the study of disease dynamics in defined animal populations based on mass occurrence [25]. Four main elements of epizoology are (i) the pathogen population, (ii) the host population, (iii) transmission, and (iv) the environment [25]. Parasitism is a +/- type of non-mutual species-specific ecological relationship and the obligate association between species wherein one organism, the parasite, resides either on or within the body of another organism, the host, which the parasite utilizes as habitat and depends on for its resource acquisition for nourishment and reproduction, thus causing it some damage (possibly the death) and both are morphologically, physiologically, phylogenetically, and ecologically adapted to this mode of life [26]. The term parasitism is originated from Latin *parasitus* and the Latinization of Greek *parasitos* means "one who eats at the table of another and that from (*para*) = "besides, by" + (*sitos*) = "wheat" hence, "food" [43]. The entomologist E. O. Wilson has described parasites as "predators that eat prey in parts of smaller than single". The host-parasite interactions are complex and both co-evolve [49].

The livestock sector is a chief part of the world's wealth, especially in developing countries. According to Food and Agriculture Organization (FAO), 2004 reports, India account for a phenomenal portion of the world's livestock resources with about 57% of the world's buffaloes, 16.5% of cattle, and 16.3% of goats, and 5.7% of sheep [20]. India is the topmost milk-producing country globally [30]. As stated in the 19th Livestock Census (2012), Uttar Pradesh (U.P.) ranks second for cattle population in India [2]. The total value-added from the livestock sector in the U.P. adds up to more than 916 billion INR in the fiscal year 2019. The third-largest economy of India, the northern provinces of the Gangetic plains contributed over 12% to the economic value in India from this sector [16]. Uttar Pradesh is the highest milk-producing state in India, contributing around 18% to the total milk production (about 30.5 million metric tonnes).

Cattle occupy a distinctive part in human history as they are tamed since the prehistoric period [10]. Cows are well-known domesticated and devoted animals. The cow is religious, like the holy river Ganga, among all

domesticated animals. The cow is regarded as the *jeevandadtri*, 'the life-giver [9]. The relevance of cows (*Gaumata*) in Indian society is intermediary religiousness and prudence [1]. They are considered versatile since domesticated for milk and other dairy products, for hides to make leather, for meat (beef), as draught animals for agricultural land preparation, and for transporting goods, carting, raking, threshing, and crushing of sugarcane and oilseeds in rural areas during inter-culture [22]. Other important products of cattle are their dung (which can be used to make manure or biogas) and urine, the *Gomutra* (pharmaceutically significant for making vaccines including that for COVID-19) [19]. Cattle are the key roots of greenhouse gas emissions from livestock and are responsible for 10% worldwide [21].

The parasites that shelter on the host's body surface are known as ectoparasites. The expansion of parasites, particularly ectoparasites, is a serious veterinary challenge in most developing and developed countries internationally [17]. Among the various ectoparasites including lice, ticks, mites, etc., ticks are the most paramount [44] and most important parasites affecting various vertebrate hosts, including humans [14, 29]. Ticks are primitive, obligate, blood-sucking parasites that prey on every class of vertebrates worldwide [5]. Ticks pertain to the phylum Arthropoda and order Acarina. Families Argasidae (185 species), Ixodidae (713 species), and Nuttalliellidae (1 species) including 899 tick species known to parasitize the vertebrates [5]. Ixodidae or hard ticks feed for prolonged periods on their hosts, from a few days to weeks, as per the life phase, hosts, and species. The external cuticle of Ixodid ticks enlarges to store sucked blood, which, in adult ticks, is almost 400 times their empty body weight.

Ticks are of huge veterinary and medical significance. The ticks follow mosquitoes as carriers of communicable germs in humans and animals [33]. Ticks account for the huge loss of yields largely because of the direct loss due to loss of blood and impaired skin and the indirect loss due to the transmission of disease-inducing pathogens [8, 11]. Being obligate hematophagous ticks act as vectors of many serious diseases that affect humans and other animals and spread a large variety of pathogens such as viruses, bacteria, and protozoa, surpassing any other arthropod vector [11, 27]. They carry diseases that are a significant hurdle to livestock output [24]. Ticks living on livestock can impoverish the quality of animal products and can even cause death [18]. A female tick can cause anaemia that reduces the milk yield, dry matter intake, and live weight gain of cattle. Ticks act double trouble as potential vectors and reservoirs of certain infectious agents, e.g. *Salmonella, Brucella, and Pasteurella spp.* in man and animals [32]. Almost every genus of livestock is vulnerable to the infestation of ticks [20]. During the past twenty years, the cases of Tick and Tick-Borne Diseases (TTBDs) have occurred increasingly as prominent anthropogenic and zoological health issues [13]. The annual control cost of TTBDs has been computed as 498.7 million US$ (~2000 crores) [27, 50]. The most extensive effects of TTBDs in the Indian dairy sector are a drop in milk production i.e., a decrease of 14% in lactation [27], and diminished quality of hides for the leather industry [7, 32].

According to FAO (2004), TTBDs affect 80 % of the world's cattle population [20] and are widely distributed worldwide [45], notably high in the tropics and subtropics. The optimal temperature and relative humidity required for ticks growth and reproduction are 26-37°C and 85%, respectively [3]. Ticks develop more in warm and humid climates. In addition, the large populations of wild animals in warm countries provide a reservoir of ticks and infective microbes that spread to domestic animals. Since the ticks spend most of their time in the environment, Climate change is likely to influence their distribution and abundance, and disease prevalence by affecting the faunal diversity (the butterfly effect) [23]. Tick populations are spreading into new areas, due in part to the warming temperatures of climate change [28]. Ticks are pervasive in all agro-ecological zones of India [27]. The cases and occurrence of Ixodid ticks were studied from different parts of the country viz. Punjab, Haryana [12], Rajasthan, Gujarat [6], Maharashtra [31], Uttar Pradesh [4, 36], Uttarakhand, West Bengal, Kerala, and Tamil Nadu [38, 42]. The species of ticks are cosmopolitan in India and various surveyors have reported the spread and occurrence of tick species in several districts in the country. In India about 106 tick species have been recorded, still, the organized survey of the ticks in numerous regions is yet scant. Although from Uttar Pradesh, over 42 species have been reported, still the ticks are very sparse [4, 36]. A valid data of Ixodid ticks prevalent in cattle in the area is still not available, which obstructs the tick control and management. The introduction of data-centered science [37] and renewed efforts to determine the number of species. The study will be of high significance [15].

Considering the medical and commercial significance of ticks and the insufficiency of data on the ticks prevalence in cattle, the tailored study is designed to do the Epizoological study explaining the Morphology (morphological identification and characterization), Biodiversity, and Prevalence of Ixodid Ticks infesting the cattle in and around BBAU Campus, Lucknow, U.P.

Materials and Methods

Study Period: The study was conducted from 22nd February 2022 to 22nd April 2022 (two months). The data was recorded and analyzed.

Study area: The study was conducted in Lucknow, the capital city of U.P., in the heart of the Indo-Gangetic Plains. The area is located at 26.8467°N and 80.9462°E. The study area, BBAU campus, and nearby region were divided into five zones of random sampling viz., North (Rajini Khand, Telibagh); East (Piprouli, Ishwari Kheda); West (Aurangabad, Bijnaur); South (Utrethia, Kalli Paschim); and Central (BBAU Campus, Shaheed Nagar) zone for the epizoological studies (Fig. 1 A, C).

Study Animal and Sample size: In the proposed study, 135 cattle of the genus *Bos spp.*, common livestock in the region as per their sexes, breeds, and ages were selected and examined for the tick infestations (Fig. 1 B).

Study Design and Epidemiological Survey: The animals were randomly selected and examined properly for any presence of ticks. The selected sites were visited several times to do a cross-sectional study and dialogue with rearers for gathering information.
For the appropriacy of the study, the cattle were sorted according to the breed (indigenous milch breeds: Gir, Sahiwal; exotic: Holstein Friesian, Jersey, and crossbreed: Frieswal, etc.), sex (male or female), site of attachment (ear, dewlap, flank, udder, external genitalia), age groups (<2, 2-8, >8 years), management practices (extensive, sem-intensive, intensive) and months (March and April 2022) [34, 46].

Collection of Test Organism: A random collection of adult ticks from various body sites of the cattle. Ticks of varying engorgement were twitched off from the cattle hides with the help of blunt forceps making an angle of 45° to the host body, carefully without damaging their mouthparts (Fig. 1 D).

Preservation of Sample: In 70% alcohol, the adult ticks were stored in glass vials separately, labeled with the area within the date of collection, zone, and the breed, sex, age, and the number of the samples, in well-stopped glass vials. These samples were brought to Laboratory No.1 of the Department of Zoology, B.B.A.U., Lucknow for permanent mounting and morphological recognition (Fig. 1 E).

Light and Optical microscopy: Permanent slides of ticks were prepared. For permanent mounting, the preserved samples were washed in distilled water to remove 70% ethanol. Washed samples were heated in 10% KOH solution for 10-20min to remove the chitin layer and other debris using a hot water-bath heating mantle (Sonar Heating Mantle). Washed the samples again in distilled water to remove KOH. After this, the specimens were dehydrated by using different percentages of ethyl alcohol, (30%, 50%, 70%, 90%, and absolute alcohol) each for 1h. The samples were cleaned with xylene, for 1-2min. After this, the samples were D.P.X (sandwiched) mounted on glass slides and covered with coverslips. The sides of the coverslips were sealed with a coat of nail paint. The permanent slides were observed under objectives of 10x, 40x, and 100x, microscopes (Magnus SN 100x student microscope and Evos XL Imaging Digital microscope), and pictures were clicked and studied.

Scanning electron microscopy: For SEM, samples were first air-dried in a desiccator. Primary fixation was performed using 2.5% glutaraldehyde for 3-4h. Washed thrice with 0.1M PBS for 15min each. Post fixed with 1% OsO_4 and left overnight. On the next day, the samples were dehydrated with a series of acetone grades (30%, 50%, 70%, 90%, 95%, and 100%). After dehydration, samples were mounted on carbon stubs, coated with Pt, and observed at 5K and 20K under SEM (Jeol, Japan; JSM 6490 LV). Photographs were captured and examined [41] (Fig. 3 E).

Identification of ticks: Tentative identifications were made under a simple (stereoscopic) microscope. Final identifications and characterization were made under a compound microscope and scanning electron microscope for selected samples, according to the standard Keys and Descriptions.

Formulae and Statistical Analysis
Evaluation of Biodiversity Index: The Shannon Diversity Index is one of the most commonly used diversity indexes as it incorporates both the components of biodiversity: richness and evenness. It is a simple, synthetic summary, but it is difficult to compare communities that greatly differ in richness. Typical values are generally between (-) of 1.5 and 3.5.

Shannon diversity index, $H' = -\sum_{i=1} p_i \ln p_i$

where H'= Shannon index of diversity

p_i = the proportion of the important value of the i^{th} species $p_i = \frac{n_i}{N_i}$ (, n_i is the no. of individuals of a particular species and N_i is the no. of individuals of all the species).
High values of H' would be representative of more diverse communities. The values of H are negative (-) as the values are the natural log of p_i $(\ln p_i)$.

Percentage of Prevalence: The prevalence of ticks was recorded concerning the months of the study, management practices, breed, sex, age, and sites of predilection on cattle. The prevalence (P) was computed according to standard methods and the formula.

$$P = \frac{\text{No.of infested cattle in a specificied period}}{\text{Total No. of cattle surveyed}} \times 100$$ where, ($P = \%$ infestation)

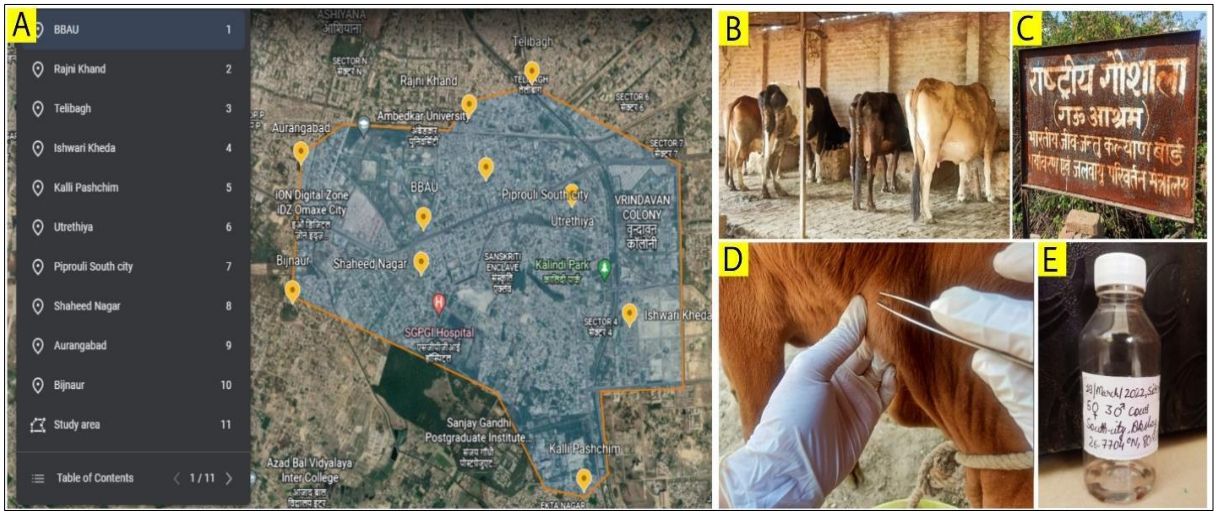

Fig 1: Various sites, Cattle, Collection, and Preservation of Ixodid ticks-(A) Map showing the sampling sites and study area (Not to Scale) (Source- Internet); (B) Cattle in private cowshed for random sampling (extensive and semi-intensive); (C) *Gaushala* (Cow shelter) for random sampling of cattle (intensive); (D) Collection of samples using forceps; (E) Preservation of samples in 70% ethanol in vials

Results

Morphological characterization of Ixodid ticks under light and optical microscopy

Eight legs in the adult and nymphal stages (six legs in the larval stage). Dorso-ventrally ovoid or pear-shaped dark (black or brown) colored flattened and small 2-5mm sized body (idiosomas) (when not engorged) and large, round, and silver-white (when engorged). The dorsal plate (scutum) covers the anterior third or so of the immature stages of both genders and adult females. Mouthparts directed anteriorly (beak-like prognathous) are visible from above. The cephalothorax and abdomen are completely fused.

Male and female hard ticks appear visually distinguishable from each other (sexual dimorphism) Males are generally smaller than females. The dorsal scutum spans nearly the entire dorsum of adult males and is inflexible (conscutum), while among feeding females and immatures the scutum is less than half the size of males, and is limited to a small region directly behind the head, facilitating the expansion of softer cuticle (alloscutum) (Fig. 2 A-F).

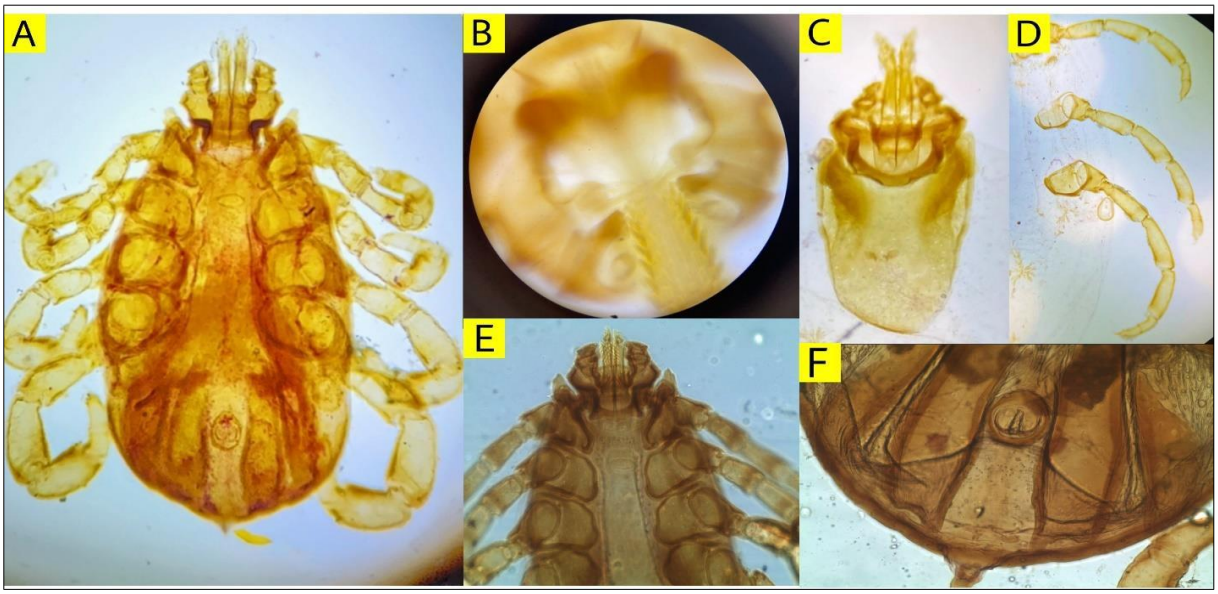

Fig 2: Light and Optical Micrographs of Ixodid ticks-
(A) Whole mount showing ventral side; (B) Enlarged view of ventral side of Mouthparts; (C) Dorsal side of capitulum; (D) Lateral view of the body portion showing legs; (E) Anterior portion of the body; (F) Posterior portion of the body

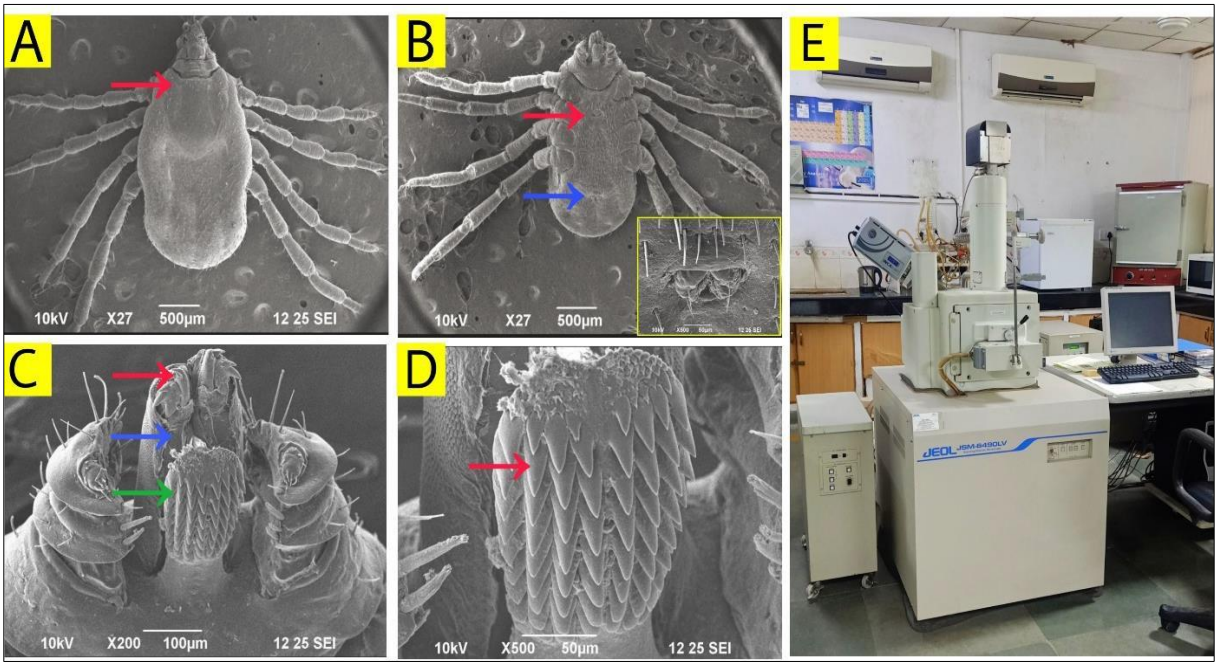

Fig 3: Scanning Electron Micrographs of Ixodid ticks-
(A) Dorsal side of whole mount showing the scutum; (B) Ventral side of whole mount showing genital aperture and anus, Enclosing a box showing enlarged view of anus; (C) Ventral side of capitulum showing Chelicerae, Palps and Hypostome; (D) Enlarged ventral side of barbed Hypostome showing dentines; (E) SEM unit, USIC, B.B.A.U. Lucknow

The ultrastructure of Ixodid ticks as observed in Scanning electron microscopy

The larvae have three pairs of legs and no genital aperture. Nymphs (immature adults) have four pairs of legs and no genital aperture. Adult females have four pairs of legs and a large genital aperture. Adult males have four pairs of legs and a genital aperture in the same position as females. Typically, nymphs and adults were taken to the diagnostic laboratory for identification.

Larva and nymphs can usually be placed in the correct genus by comparison with the mouthparts, coxae, and other similar features of adults. Important features for genus-level identification include the length of the piercing and sucking type mouthparts (a barbed feeding tube, hypostome for piercing and sucking, chelicerae for cutting and sensory palps) about the basis capitula (together called capitulum = head), presence/absence of eyes, presence/absence of festoons (posterior marginal irregular folds and grooves), shape and location of the anal groove, and presence and have distinctive white patterns on scutum (ornate) / mostly inornate and appear brown absence of pale maculae (markings) on the dorsal shield (Fig. 3 A-D).

The life cycle of Ixodid ticks

Ticks are versatile animals and some show 'questing behavior' to get onto their hosts. Ticks wait on vegetation held by the third and fourth pairs of legs, for long periods. When ticks sense a host approaching, ticks stretch out their front legs to grasp the hair coat of the host. Ticks locate potential hosts by sensing odour (olfaction of butyric acid and CO_2), body heat, moisture, infrared light, and/or vibrations in the environment by Haller's organ (unique tiny sensory pit in the tarsus of leg I) When stationary, their legs remain tightly folded against the body. Hard ticks have a four-stage life cycle: egg, larva, nymph, and adult. Most hard ticks have a rare one-, two- or the most common three-host life cycle, and the tick leaves the host between each blood meal during the larval, nymphal, and adult stages.

The economic impact of ticks

The ticks cause heavy losses to the livestock. In some cases, ticks have been reported to cause stunted growth, poor development, reduced yields, and raised mortality. Ticks living on livestock can reduce the quality of animal products and even be fatal to livestock. An adult female tick can cause anaemia that reduces the milk yield, dry matter intake, and live weight gain of cattle.

Shannon Diversity Index of the ticks collected was evaluated after successful identification and enumeration. After observing and computing, the following results were obtained (Table 1):-

Shannon Diversity Index = -1.1 (desirable value = 1.5-3.5)
The abundance of Ticks = 24 ticks per line transect
The density of Ticks = 21 ticks per quadrat
Species richness of ticks = Rich (various species) and diverse.
Composition of ticks = Clumped (positive interaction)

Table 1: Observation table showing ticks diversity in the study area-

S. No.	Name	Days / Quadrats / Zones					No. of Individuals (n)	Pi	lnPi (-)	Pi*lnPi (-)	%Species Composition	Abundance	Density
		1	2	3	4	5							
1.	*R. microplus*	15	10	8	12	13	58	0.56	0.58	0.39	56.31	11	12
2.	*R. sanguineus*	1	1	0	3	0	5	0.05	2.99	0.28	4.85	1	1
3.	*Hyalomma*	4	0	5	4	10	23	0.22	1.51	0.42	22.34	6	5
4.	*Haemaphysalis*	0	7	6	0	4	17	0.17	1.77	0.40	16.50	6	3
∑	Total values = 4 species	5 days/ line transects					103	1	-6.86	-1.1	100	24	21

Prevalence of Ticks

135 cattle were surveyed during the study, and 79 cattle of which were found to record the presence of ticks (58.51%) due to lack of awareness and ignorance. 4 species of ticks (103) were found, *R. microplus* and male ticks were more prevalent (62) than females (41) because female ticks fall off the host's body on the ground after feeding. The younger cattle (<2yrs) were found to have a higher infection (78.57%) due to weaker immunity. Adult female cattle have a significant infection (80%) of ignorance and less care than milk-producing females, which in turn also have a 50% ticks prevalence due to hormonal stress.

Exotic breeds showed more prevalence (83.78%) than local breeds which have developed immunity against the ticks. A good no. of ticks (36) almost 34.95% were found in the dewlap region of the cow's body, due to many skin folds. 64.06% of tick infestation was found in intensive management practices due to the overcrowding of animals. April 2022 recorded more infections (56.96%) because of the favorable warmer and humid climate for the growth of ticks. The western zone of the study area had a significant tick prevalence (67.74%) due to higher temperatures and semi-arid climates (Fig. 4 and Table 2).

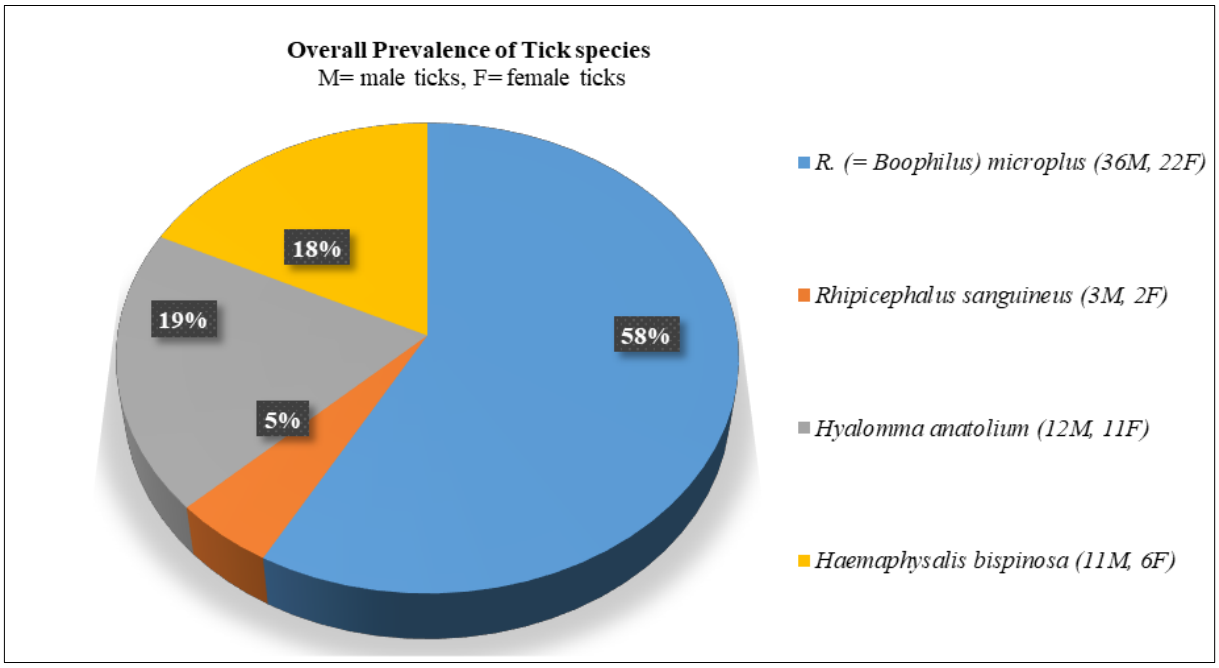

Fig 4: Overall prevalence of Ixodid Ticks in cattle, Tick species and sex-wise.

Table 2: Attributes of the Host cattle (age, sex, breed, and predilection sites), Management practices, Months and zones of study-

S. No.	Attributes of Cattle	Total no. of individuals	Desired no. of individuals	Prevalence (%)
	(A) Overall prevalence			
1.	Total	135	79	58.51
2.	<2 years	28	22	78.57
3.	2-8 years	24	15	62.50
4.	>8 years	83	42	50.60
	(B) Sexes-wise			
5.	Male	40	32	80.00
6.	Female	95	47	49.47

(C) Breeds-wise				
7.	Indigenous	93	45	48.38
8.	Exotic	37	31	83.78
9.	Cross	5	3	60.00
(D) Predilection sites-wise				
10.	Ear	103	9	8.74
11.	Dewlap	103	36	34.95
12.	Flank	103	27	26.21
13.	Udder	103	13	12.63
14.	Genitals	103	18	17.47
(E) Management Practices-wise				
15.	Extensive	23	11	47.83
16.	Semi intensive	48	27	56.25
17.	Intensive	64	41	64.06
(F) Months-wise				
18.	March 2022	79	34	43.04
19.	April 2022	79	45	56.96
(G) Zones-wise				
20.	North	17	9	52.00
21.	East	14	7	50.00
22.	West	31	21	67.74
23.	South	52	29	55.76
24.	Central	21	13	61.90

Discussion

The distribution and abundance of tick species infesting cattle show a wide range over the area. The examination of ticks on livestock, in uncontrolled conditions, is also useful for comprehending the host-parasite relationship and the dynamics of the tick population. The study of the distribution statistics of ticks in the different agricultural and climatic areas would help in designing a strategic control of ticks and diseases caused by them. The Green audit of the BBAU campus showed that it possesses a good number of cattle. Moreover, the stray cattle due to over-infestation are not taken care of properly. Such ownerless (feral) cattle along with being a carrier of TTBDs (Tick and Tick-borne diseases) also meet with many road accidents, attacks from other animals like dogs, etc. Though recent efforts are made in this domain of animal science, such as by Dilpreet Kaur in 2017 [35], Neeraj Kumar in 2019 [40], and Awanish Kumar in 2021; still a systematic survey on Ixodid ticks infesting cattle in the area is not available, which obstructs the tick control and management. Considering the agro-economic, medical and veterinary importance of ticks and the insufficiency of data on the prevalence of ticks on cattle, the proposed study is framed to gather, recognize and calculate the infestations of Ixodid ticks on cattle in and around the BBAU campus, Uttar Pradesh.

From the study conducted, it was inferred that more than half the population of the investigated cattle were found to be infested with four species of Ixodid ticks (Fig. 4). Various surveys on the occurrence of Ixodid ticks have been conducted by many workers in India [4]. The percentage found in the study is congruent to a study in Mathura, where 2515 cattle were examined and an infection rate of 60.07% was found. Few studies have reported more than half of the prevalence in cattle; however, others have reported a low prevalence rate of tick infestation (<45%) [47, 48] of the cattle rearers in rural areas contributed to the higher occurrence of tick species in the observed region. The deviations in the infestations found in the conducted study in contrast to preceeding studies by different surveyors may be attributed to the changes in geographical and climatic variables of the observation region, and the procedure used for the study [34]. In this study, *Rhipicephalus (Boophilus) microplus* was recorded to have a significant occurrence (Fig. 4 and Table 1) whereas *Hyalomma analoticum* was found to be of common occurrence in cattle in the Mathura (21.59 %). *Rhipicephalus (Boophilus) microplus* is reported as the most prevalent tick in U.P. and Tamil Nadu by some workers [38]. *H. bispinosa* is recorded as the most prevalent tick infesting multiple species of domestic animals in Kerala. In another study, the tick species *Haemaphysalis bispinosa is* a more prevalent species infesting not only cattle and buffaloes, but also goats and sheep, and even some monkeys [42].

The male to the female sex (M: F) ratio of the ticks examined was found to be >1 (Table 2). Thus, the male ticks were found to be more prevalent in comparison to the female ticks, possibly because fully engorged female ticks drop off on the ground for laying eggs while the males remain attached to the host and continue feeding and reproducing. The careful observation and analysis of tick and cow interactions are very important to assess the infestation levels and thus reduce the loss of both biodiversity and the economics of dairy. The religious sentiments of Hindus associated with cows should be respected and utilized in protecting the cattle from any unnatural treatment. The results are in coherence with the previous work done. Another interesting and unique finding is that the prevalence of Ixodid ticks infestation is found to be of higher level in male cattle instead in females (Table 2). This can be attributed to the ignorance in the care given to the male cattle in comparison to

female cattle, mainly used as dairy animals. In addition, the integration of Biostatics and Epizoology is attempted for building a strong understanding of the aims of this study.

Conclusion

Parasitism is a complex occurrence in nature. This complexion further becomes challenging while understanding the host-parasite interactions. Such a phenomenon is one of nature's mysteries. However, epizoology can be used as a clue, in integration with biosystematics and taxonomy. This can help in understanding the morphology, behavior, biodiversity, and prevalence of pathogens. In India, a bigger share of GDP and economy is provided by agriculture and livestock. The sub-tropical climate makes it more prone to the risks involving the rapid infections of ticks in the cattle.

Cow being the epicenter of the dairy industry ensures food security by providing a rich source of proteins. The holy symbol, cows have been in the news headlines recently but for not-so-good reasons. A careful and futuristic approach should be devised to resolve the issues related to stray cows. Livestock faces a life-threatening danger from ticks, overtaking all the other arthrodial infections, along with mites. The conducted study concerning the epidemiological investigations of tick prevalence involved studying morphology, biodiversity, and prevalence of the Ixodid Ticks infesting the cattle in and near the BBAU campus, Lucknow. Various methods such as light and scanning electron microscopy in addition to biostatistics were adopted to accomplish the study.

The significant and prevalent tick species found during the study were *Rhipicephalus (Boophilus) microplus*, *Hyalomma analyticalm*, *Haemaphysalis bispinosa*, and *R. sanguineus* (Fig. 5). From the study, it is inferred that although there is a heavy infestation of the cattle reared in the area due to inadequate attention. The results of the current study showed that the prevalence of ticks has a seasonal prevalence and selective host preferences and depends on the rearing and management practices of the rearers. The findings from the conducted study may add to the improved and updated comprehension of the epizootiology of ticks in the study area. It was noted that improved attention should be given to tick distribution patterns on different attachment sites on the host body, tick prevalence, and other host breeds (Table 2) to derive better inferences about the vulnerability of the cattle host to tick infestation resulting in a better understanding of its prevention and control.

There seems to be a relation between Ixodid tick infestation rates and coat colour, hair type, texture, etc. of the host. The low percentage of prevalence in indigenous *Bos indicus* shows that it developed some innate resistance against the Ixodid tick infections in comparison to the exotic breeds *Bos taurus*. Proper hygiene, applications of acaricides like Amitraz, phytochemicals like eucalyptus oil, neem extract, etc., ethnoveterinary practices like the use of lime powder, etc., and physical removal with combing or hand removal by wearing gloves, etc. could be adhered to for reducing the Ixodid tick infestation cases.

The results found are being validated and in turn, validate the previous work done in this direction. The applicability of the work is not only to support the work done in the past but also to boost and foster the research in the 'un-touched' aspects. Despite the best measures taken into consideration while identifying the tick species studied, simply relying on traditional techniques is doubtful. However, for the accurate identification of tick species, some molecular studies can be conducted in the future. Moreover, establishing the dynamic relationship between host and parasite that influences its distribution and 'questing' interdependence can be a subject of futuristic objectives.

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