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Research Article

Seroprevalence and Risk Factors Associated with Caprine Arthritis Encephalitis Virus Infection in Goats: Insights from Three Egyptian Governorates

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Abstract

This study aimed to determine the seroprevalence of caprine arthritis encephalitis virus (CAEV) in goats in three northern Egyptian governorates (Kafr El Sheikh, Beheira, and Alexandria) and assess the associated risk factors. A total of 415 goats were sampled, with serological analysis conducted using an cELISA test. The overall seroprevalence of CAEV was found to be 9.6%, with significant variation observed based on sex, age, breed, production system, and farm management practices. The results indicated higher seroprevalence in females, older goats, and certain breeds such as the Egyptian Baladi, as well as in dairy goats. Additionally, poor biosecurity management and contact with other herds were identified as significant risk factors. This study provides valuable insights into the epidemiology of CAEV in Egypt and underscores the need for improved control measures to mitigate the spread of the virus. Further research is recommended to explore the full extent of CAEV infection in goat populations and to enhance the understanding of its impact on goat farming in the region.

Keywords: Caprine Arthritis Encephalitis Virus, cELISA; Risk factor, Goat, Egypt

Introduction

Caprine arthritis and encephalitis (CAE) is a fetal viral disease of goats, caused by the caprine arthritis-encephalitis virus (CAEV), a lentivirus belonging to the *Retroviridae* family [1]. It induces multisystemic diseases in sheep and goats [2]. Lentivirus infections produce persistent, progressive, and fatal infections in many target organs, including carpal joints, the mammary gland, lungs and central nervous system [3,4]. This can affect milk production and increased the risk of developing mastitis [5,6].

The disease causes mastitis, severe arthritis, and possibly interstitial pneumonia in adults, while causes encephalitis in young goats [7]. Also, CAEV infections can cause synovitis, lameness, joint enlargement and reduction in growth rate [3,7,8]. The disease causes economic losses resulting from reduced yield from subclinical infections, decreased value of culled animals, mortality from clinical sickness, and ultimately a shorter economic lifespan of affected goats [9,10].

Transmission of CAEV can occur both horizontally and vertically [11]. Horizontal transmission results from direct contact with intimate contact of diseased animals, body fluids, and excretions, while vertical transmission happens through consumption of contaminated milk or colostrum [12-14].

Once the virus enters the body, the host becomes permanently infected. Additionally, cases of interspecies transmission, especially, goat-to-sheep and sheep-to-goat can occur spontaneously within mixed populations [15].

CAEV is distributed worldwide [16]. It has been reported in numerous places of the world since its first identification in goats in 1974 [17]. The prevalence of CAEV varies by country, ranging from 1.9% in Turkey and 3.6% in Mexico to 82% in Australia and 73% in the USA [18]. In Thailand, the prevalence of CAEV was 12.4% [19].

Diagnosis of the diseases depends mainly on clinical signs, postmortem lesions and histopathological findings [20]. Serological tests are the primary method for detecting CAEV due to the persistence of antibodies against virus in circulation. Serological techniques to detect CAEV include enzyme-linked immunosorbent assay (ELISA), agar gel immunodiffusion (AGID) and indirect immunofluorescence [7,9,21]. In addition, the most widely used serological test in for identifying CAEV infection is the ELISA, because it is more sensitive than AGID [3].

Currently, there is no effective therapy or vaccination for the condition and improving diagnostic test quality and efficacy could potentially eliminate it. However, early diagnosis of CAEV infection using serological approaches remains crucial for prevention, eradication and control [22-24].

The study aimed to determine the seroprevalence of CAEV in goats across three Egyptian governorates and assess the risk factors associated with the infection to provide valuable insights into the epidemiology of the disease in the region.

Materials and Methods

Ethical Statement

The research protocol was reviewed and approved by the Institutional Animal Care and Use Committee at Faculty of Veterinary Medicine, Benha University, ensuring adherence to guidelines. (Ethical No: BUFVTM 20-11-2024). Informed consent was obtained from all goat owners prior to sample collection. The procedures involved, including blood sample collection, were performed by trained veterinarians to minimize animal discomfort and ensure their welfare. No animals were subjected to unnecessary harm, and all efforts were made to reduce stress during handling. All methods are reported in accordance with ARRIVE guidelines.

Study Area

The study was conducted from January to December 2023 in three Egyptian governorates: Kafr El-Sheikh, Beheira, and Alexandria *(Fig. 1)*. These governorates are situated in the northern part of Egypt, each with distinct geographical and climatic characteristics. These governorates (Kafr El-Sheikh, Beheira, and Alexandria) were selected because they are agricultural areas with a high animal population.

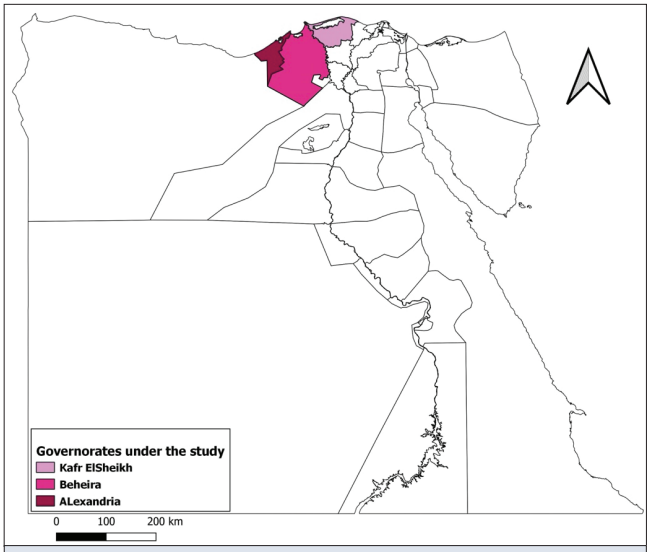

Fig 1. Map showed the governorates under the study (MAP generated by QGIS software)

Kafr ElSheikh is located in the Nile Delta, bordered by the Mediterranean Sea to the north. The governorate has a Mediterranean climate with mild, wet winters and hot, dry summers, which supports extensive agricultural activities and livestock farming. Beheira is situated in the western part of the Nile Delta and like Kafr El-Sheikh, it has a Mediterranean climate, with higher humidity levels due to its proximity to the sea and irrigated lands. In addition, Alexandris is located along the Mediterranean coast, it is Egypt's primary port city and has urban and peri-urban areas where livestock farming exists. It has a temperate Mediterranean climate with relatively higher humidity and moderate rainfall during winter, compared to the inland governorates.

Sample Size and Sampling

To determine the sample size for assessing the sero-prevalence of CAEV in goats, the formula by Thrusfield [25] was applied:

$$N=Z^2P_{exp}(1-P_{exp})/d^2$$

Where:

N = Required sample size

Pexp = Expected prevalence (assumed at 8.52% as previously reported by Baraka, Khadr [26])

Z = Standard normal deviate for a 95% confidence interval (1.96)

d = Desired margin of error (5% or 0.05)

The calculated sample size for determining the seroprevalence of CAEV was 119, based on the formula by Thrusfield. However, to enhance precision and reliability, the sample size was increased to 415 to increase precision. Blood samples were collected from the jugular vein of goats. Blood samples were centrifuged at 3000 rpm for 10 min to separate sera. Sera were then carefully aliquoted and preserved at −20°C until they were subjected to serological examination.

Serological Analysis

A commercial ELISA kit (ID Screen® MDV/CAEV Indirect, ID vet, France) was used to screen all collected sera for anti-CAEV antibodies in accordance with the manufacturer's instructions. A microplate reader (ALLSheng A101; China) was used to read the OD value at 450 nm.

Samples were considered positive for the CAEV if their percentage of inhibition (PI) was greater than 60%. The kit's sensitivity and specificity rates for identifying CAEV antibodies in small ruminants are 99.3% and 99.7%, respectively [27].

Statistical Analysis

Statistical analysis was performed using SPSS software (IBM SPSS 24, USA). To assess the statistical significance between various factors and the seroprevalence of CAEV infection, the Chi-square (χ^2) test was used. A logistic regression analysis was then carried out to explore the relationship between CAEV antibodies and risk factors such as locality, sex, age, breed, production system, flock size, rearing with sheep, contact with other goat herds and biosecurity status. Variables that had a P-value of less than 0.25 in the univariable analysis were included in a multivariable logistic regression model. This model provided the odds ratios (ORs) and confidence intervals (CIs) for each significant variable. The model's goodness-of-fit was assessed using the Hosmer-Lemeshow test.

Results

The overall seroprevalence of CAEV in goats was found to be 9.6% (40/415), with no statistically significant differences (P=0.301) observed among the examined governorates. However, Alexandria governorate exhibited the highest seroprevalence at 12.4%, (18/145) *(Table 1)*.

Table 1. *The seroprevalence of Caprine Arthritis Encephalitis Virus in goats in relation to different studied factors*

Variable		Total Examined Animals	No of Positive	No of Negative	% of Positive	95% CI	Statistic
Locality	Kafr ElSheikh	130	9	121	6.9	3.68-12.63	χ2=2.403 df=2 P=0.301
	Beheira	140	13	127	9.3	5.51-15.24	
	Alexandria	145	18	127	12.4	8-18.76	
Sex	Male	80	4	76	5.0	1.96-12.16	χ2=2.448 df=1 P=0.118
	Female	335	36	299	10.7	7.87-14.52	
Age	≤1	111	4	107	3.6	1.41-8.9	χ2=9.085 df=2 P=0.011*
	1-2	179	17	162	9.5	6.02-14.69	
	>2	125	19	106	15.2	9.95-22.52	
Breed	Egyptian Baladi	166	25	141	15.1	10.41-21.29	χ2=9.797 df=2 P=0.007*
	Zaraibi	140	10	130	7.1	3.92-12.65	
	Damascus (Shami)	109	5	104	4.6	1.98-10.29	
Production system	Meat	134	8	126	6.0	3.06-11.34	χ2=3.058 df=1 P=0.080
	Dairy	281	32	249	11.4	8.18-15.64	
Flock size	<30	320	36	284	11.3	8.24-15.18	χ2=4.168 df=1 P=0.041*
	>30	95	4	91	4.2	1.65-10.33	
Rearing with sheep	Yes	264	27	237	10.2	7.13-14.47	χ2=0.289 df=1 P=0.591
	No	151	13	138	8.6	5.1-14.17	
Contact with other goat herds	Yes	245	31	214	12.7	9.06-17.4	χ2=6.240 df=1 P=0.021*
	No	170	9	161	5.3	2.81-9.75	
Biosecurity status	Good	153	7	146	4.6	2.24-9.15	χ2=7.134 df=1 P=0.008*
	Poor	262	33	229	12.6	9.08-17.1	
Total		415	40	375	9.6	7.16-12.86	

**Results are significant if P<0.05*

Table 2. *Multivariable logistic regression analysis for risk factors associated with seropositivity of Caprine Arthritis Encephalitis Virus in goats*

Variable		B	S.E.	OR	95% C.I. for OR		P Value
					Lower	Upper	
Sex	Female	0.873	0.567	2.4	0.8	7.3	0.012
Age	1-2	0.757	0.590	2.1	0.7	6.8	0.020
	>2	1.329	0.589	3.8	1.2	12.0	0.024
Breed	Egyptian Baladi	1.295	0.527	3.6	1.3	10.3	0.014
	Zaraibi	0.423	0.585	1.5	0.5	4.8	0.036
Production system	Dairy	0.917	0.437	2.5	1.1	5.9	0.036
Flock size	<30	0.879	0.561	2.4	0.8	7.2	0.011
Contact with other goat herds	Yes	0.921	0.413	2.5	1.1	5.6	0.026
Biosecurity status	Poor	1.216	0.452	3.4	1.4	8.2	0.007

B: Logistic regression coefficient, SE: Standard error, OR: Odds ratio, CI: Confidence interval

The seroprevalence of CAEV was higher in females (10.7%) compared to males (5%) and was significantly elevated in goats older than two years (15.2%). Furthermore, the seroprevalence varied among breeds, with the Egyptian Baladi breed showing the highest rate (15.1%), followed by Zaraibi (7.1%) and Shami (4.6%). Notably, goats bred for dairy production exhibited a higher seroprevalence (11.4%) compared to other purposes *(Table 1)*.

Interestingly, goats that had contact with other goat flocks or were raised in small flocks of fewer than 30 animals demonstrated significantly higher seropositivity for CAEV. Additionally, inadequate biosecurity measures were associated with a significantly increased likelihood of CAEV infection, underscoring the critical role of effective management practices in controlling the spread of the virus.

The multivariable logistic regression analysis revealed several significant factors associated with the likelihood of CAEV infection in goats. Female goats were at higher risk (OR = 2.4, 95% CI: 0.8–7.3), as were older animals over two years of age (OR = 3.8, 95% CI: 1.2-12). The Egyptian Baladi breed showed a markedly increased likelihood of infection (OR = 3.6, 95% CI: 1.3-10.3), and goats bred for dairy production were also more susceptible (OR = 2.5, 95% CI: 1.1-5.9) *(Table 2)*.

Furthermore, goats raised in smaller flocks with fewer than 30 animals exhibited a higher risk (OR = 2.4, 95% CI: 0.8-7.2). The risk was also elevated for goats in contact with other herds (OR = 2.5, 95% CI: 1.1-5.6) and those kept under poor biosecurity conditions (OR = 3.4, 95% CI: 1.4-8.2) *(Table 2)*.

Discussion

Goats are susceptible to caprine arthritis and encephalitis, which has a major negative economic impact and causes chronic weariness. Although a small percentage of goats may display specific symptoms, the disease usually manifests as subclinical. Goats infected with CAEV are more likely to suffer from neurological problems, arthritis, chronic mastitis, and prolonged pneumonia. These circumstances considerably lower productivity and reproductive potential, which raises the illness and mortality rates among afflicted goats [28-31].

This study aimed to determine the seroprevalence of CAEV in goats across three northern Egyptian governorates-Kafr El Sheikh, Beheira, and Alexandria-and to evaluate the associated risk factors influencing infection rates.

The overall seroprevalence of CAEV in the current study was 9.6%, aligning closely with the previously reported prevalence in Egypt (8.52%) [26] but showing variability when compared to other regions. It was lower than the prevalence reported in Jordan (8.9%) [18], Somalia (6.0%) [32], Syria (12.1%) [33], and Brazil (14.1% and 8.2%) [34,35]. Significantly higher rates have been reported in regions like Norway (42%) [36] and the United States (31%) [37].

Conversely, the prevalence in this study was higher than those documented in Saudi Arabia (0.8%) [38], Mexico (0.4%) [39], Turkey (1.9%) [40], and Italy (4.0%) [41]. This variation reflects the influence of diverse geographical, management, and climatic factors, as well as differences in diagnostic methodologies and population characteristics [42-46].

Regarding sex-based differences, the seroprevalence of CAEV was notably higher in females, consistent with previous findings reported by Ratanapob, Rukkwamsuk [19]. This could be attributed to physiological stressors like pregnancy, lactation, or hormonal changes, which may predispose females to higher susceptibility or immune responses to CAEV infection [7,32]. Interestingly, contrary

findings were noted in a study conducted in Thailand, where male goats, specifically exhibited higher seroprevalence [43]. This variability highlights the importance of considering local factors, management practices, and sample population characteristics when interpreting sex-related differences in CAEV seroprevalence [47-51].

This study observed that the seroprevalence of CAEV antibodies increased with age, rising from 3.6% in goats under one year to 15.2% in those older than two years. Similarly, Cutlip, Lehmkuhl [37] and Al-Qudah, Al-Majali [18] also reported that seroprevalence increased with age, with the latter noting a significantly higher prevalence in goats older than three years.

The age-related increase in seroprevalence can be attributed to prolonged exposure to risk factors over time and the lifelong persistence of CAEV in infected hosts [43]. Contrasting findings have also been reported. For instance, Dawson and Wilesmith [52] observed the highest prevalence in yearlings, suggesting that local management practices, herd dynamics, or diagnostic methodologies could influence age-related seroprevalence patterns.

Goat breeds demonstrated significant associations with seropositivity for CAEV infection in the univariate analysis. Notably, the seroprevalence was significantly higher in native breeds compared to others. Contrarily, Baraka, Khadr [26] observed seropositivity exclusively in Barki breed goats, highlighting potential breed-specific vulnerability or differences in exposure risks. This suggesting that genetic or environmental factors specific to these breeds might influence susceptibility [9,43].

Regarding the production system, the seroprevalence of CAEV is notably higher in dairy goats, which aligns with previous findings [53]. This study suggests that management practices and replacement policies on dairy farms may contribute to the higher seroprevalence of CAEV infection. Meat goats, which are often sold seasonally, have less prolonged exposure within the herd, reducing their risk of infection. In contrast, dairy goats are typically kept for longer periods, increasing their likelihood of contracting and transmitting CAEV within the herd [26,43].

Herd size, particularly herds with fewer than 30 animals, was identified as a significant risk factor for CAEV seropositivity in goats. This finding contrasts with the results reported by Nyi Lin, Ngarmkum [43], which suggested a different relationship between herd size and seroprevalence. In this study, an increase in herd size was inversely proportional to the odds ratio of seropositivity, indicating that smaller herds posed a greater risk for CAEV infection. The higher risk in smaller herds might be attributed to close contact among animals, which facilitates the transmission of CAEV through direct interactions or contaminated environments [54,55].

Another important risk factor in the current study was contact with goats from other herds, which has been reported to be a risk factor in earlier research [18,39]. This can be attributed to the farm management system, where farms in close proximity often share common grazing grounds. Additionally, some adjacent farms practiced the sharing of a common buck, which further facilitates the transmission of CAEV between herds. These practices increase the likelihood of cross-herd contact and, consequently, the spread of the virus [35,40,43].

In the present study, farms with poor biosecurity management showed higher seropositivity for CAEV compared to those with good biosecurity practices. This aligns with findings by Rahman, Akther [2], who reported that inadequate biosecurity and sanitation practices significantly contribute to the spread of CAEV. Farms with effective biosecurity measures typically limit external exposure, such as restricting the introduction of infected animals and minimizing contact with contaminated equipment or personnel, leading to lower seroprevalence rates [56-58].

This study provides an overview of the seroprevalence and associated risk factors of CAEV infection in goat herds raised in northern Egypt. The findings highlight the significant factors influencing the prevalence of CAEV, such as age, sex, breed, production system, flock size and farm management practices. To gain a more complete understanding of the epidemiology of CAEV, further research is needed to examine additional farms and expand on the factors influencing CAEV transmission. Such studies would be crucial for improving the management and development of goat farming in the region, ensuring better control measures and strategies for mitigating the impact of CAEV.

Declarations

Availability of Data and Materials: The datasets used and/or analysed during the current study available from the corresponding author (A. Selim) on reasonable request.

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Competing Interests: The authors declare that they have no conflicts of interest.

Declaration of Generative Artificial Intelligence (AI): The article

and/or tables and figures were not written/created by AI and AI-assisted technologies

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