THE MAIN LIVING CONDITIONS OF IXODID TICKS: VECTORS OF DANGEROUS INFECTIOUS AGENTS FOR HUMANS AND ANIMALS

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Summary
Ixodid ticks, as vectors of various dangerous infectious agents, are key players in the epidemiology of zoonotic diseases. These ticks transmit pathogens like *Borrelia* spp., *Babesia* spp., *Rickettsia* spp., *Anaplasma* spp., and others, which cause a variety of diseases in humans and animals *(Dantas-Torres et al., 2012)*. Ticks are a significant public health threat, especially in regions where they are prevalent. The study of tick biology, ecology, and their interaction with physical and chemical environmental factors is crucial for understanding their life cycle and transmission potential *(Sonenshine & Roe, 2013)*. This review highlights the factors affecting the survival of ticks, such as temperature, humidity, UV radiation, and their susceptibility to acaricides. Moreover, control methods and strategies are discussed to minimize the risks posed by tick-borne diseases.

Key words: Ixodid ticks, tick-borne diseases, environmental factors, acaricide resistance, integrated tick management, zoonotic pathogen.

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1. Introduction

Ticks have been identified as vectors for some of the most significant zoonotic diseases worldwide. They are responsible for transmitting pathogens to both humans and animals, with diseases like Lyme disease, Rocky Mountain spotted fever, and tick-borne encephalitis among the most studied *(Bowman & Nuttall, 2008)*. These pathogens are transmitted primarily through tick feeding, which can last several days, during which ticks acquire blood meals from host organisms. Ticks' capacity to transmit pathogens is strongly influenced by their environmental conditions, which impact their survival, life cycle, and interaction with hosts *(Anderson & Magnarelli, 2008)*. Additionally, the increasing concern about tick-borne diseases is compounded by changing climate conditions, leading to shifts in tick populations and the spread of these diseases to new geographical areas *(Gray et al., 2009)*. This paper aims to explore the biology of Ixodid ticks, their ecological needs, the impact of environmental factors on their survival, and the methods used to control their populations.

2. Biology and Ecology of Ixodid Ticks

2.1. Species Composition and Distribution

Ixodid ticks, part of the family Ixodidae, are a diverse group of arachnids that are found in nearly every terrestrial ecosystem. Approximately 700 species of Ixodid ticks have been described, with the most common ones being *Ixodes scapularis*, *Dermacentor variabilis*, *Amblyomma americanum*, and *Rhipicephalus sanguineus (Sonenshine & Roe, 2013)*. These ticks can be found in forests, grasslands, urban areas, and on domestic animals. Ticks are more prevalent in temperate regions but have also spread to subtropical and tropical zones. Climate, host availability, and vegetation type strongly influence tick distribution *(Estrada-Peña et al., 2017)*.

2.2. Life Cycle and Ecological Features

The life cycle of an Ixodid tick consists of four distinct stages: egg, larva, nymph, and adult. Each developmental stage, except for the egg, requires a blood meal to progress. The timing of these stages is dependent on environmental conditions such as temperature and humidity. Ixodid ticks are typically slow feeders, with feeding durations varying from a few days to a week, depending on the life stage and species *(Sonenshine & Roe, 2013)*. Temperature plays a crucial role in tick development, with most species preferring a temperature range of 10–30°C. In contrast, extreme heat or cold can reduce tick survival rates. Humidity is another critical factor; most Ixodid ticks require high humidity levels to avoid desiccation, especially during their early life stages. These ticks tend to avoid direct sunlight, seeking refuge in moist, shaded environments, such as underleaf litter or dense vegetation, to maintain hydration *(Gray et al., 2009)*.

3. Epidemiological Significance of Ixodid Ticks

3.1. Role in the Transmission of Pathogens

Ixodid ticks are vectors for a wide range of pathogens, including bacteria, viruses, and protozoa. *Borrelia burgdorferi*, the causative agent of Lyme disease, is transmitted primarily by *Ixodes scapularis* and *Ixodes ricinus (Nicholson et al., 2009)*. These ticks can also transmit *Anaplasma phagocytophilum*, the agent of human granulocytic anaplasmosis, and *Babesia microti*, which causes babesiosis in humans. *Rickettsia rickettsii*, the agent of Rocky Mountain spotted fever, is transmitted by *Dermacentor variabilis*, while Tick-borne encephalitis virus (TBEV) is transmitted by *Ixodes* species in Eurasia *(Dantas-Torres et al., 2012)*. The ability of these ticks to transmit pathogens is influenced by various factors, including tick species, the host's immune response, and environmental conditions that affect tick survival and activity. For example, the longer a tick feeds, the higher the likelihood of pathogen transmission *(Bowman & Nuttall, 2008)*.

3.2. Epidemiological Situation in Ukraine

In recent years, Ukraine has witnessed a notable increase in the incidence of tick-borne infections among both humans and animals. This rise is largely attributed to the expansion of the habitat range of Ixodid ticks, facilitated by climate change, urbanization, changes in land use, and increased human mobility *(Zubrikova et al., 2021)*. The most prevalent tick-borne diseases in Ukraine include Lyme borreliosis, tick-borne encephalitis, and anaplasmosis, with sporadic reports of ehrlichiosis and babesiosis *(Gavva et al., 2020)*.

According to the Public Health Center of Ukraine, thousands of cases of Lyme disease are registered annually, with the highest incidence reported in the western and northern regions of the country. In particular, the Volyn, Rivne, and Zhytomyr regions are considered endemic areas, with tick infection rates reaching up to 25–30% in some localities *(PHCU, 2023)*. Tick-borne encephalitis remains less common but represents a significant public health concern due to its severe clinical manifestations and potential for outbreaks in previously non-endemic zones *(Tkachenko et al., 2019)*.

The risk of tick bites and subsequent infections increases during the spring and summer months, coinciding with the peak activity period of adult *Ixodes ricinus* and *Dermacentor* *reticulatus* ticks *(Movila et al., 2018)*. Recent studies also suggest the presence of co-infections in ticks, indicating a potential for simultaneous transmission of multiple pathogens, which complicates clinical diagnosis and treatment *(Rasgon et al., 2020)*.

The current epidemiological trends underscore the need for continued surveillance, public awareness campaigns, and the development of effective tick control strategies, particularly in the context of environmental changes and increasing tick-host interactions *(Gavva et al., 2020; Zubrikova et al., 2021)*.

3.3. Impact of Climate Change on Tick Distribution

Climate change is altering the geographic distribution of tick populations, expanding their range into new areas. Rising temperatures and changes in precipitation patterns are creating more favorable conditions for ticks, especially in regions that were previously inhospitable. In North America and Europe, warmer winters and longer warm seasons allow ticks to remain active for extended periods, leading to an increase in tick-borne diseases *(Ogden et al., 2014)*. Furthermore, the spread of ticks into higher latitudes and altitudes has been documented, with *Ixodes scapularis* now being found further north in Canada, and *Ixodes ricinus* moving into Scandinavia and other northern European countries *(Medlock et al., 2013)*. This has significant implications for public health, as people and animals in previously unaffected regions are becoming more exposed to tick-borne pathogens *(Gray et al., 2009; Semenza & Suk, 2018)*.

4. Impact of Physical and Chemical Factors on Tick Survival

4.1. Temperature and Humidity

Ticks are ectothermic organisms, meaning their body temperature is influenced by the ambient temperature. As a result, temperature plays a critical role in tick survival, activity, and development. Most Ixodid ticks prefer temperatures between 10°C and 30°C, with lower temperatures slowing their metabolic rate and reproduction, and higher temperatures leading to desiccation *(Needham & Teel, 1991)*. In particular, humidity is crucial for tick survival. Ticks are highly susceptible to dehydration, and they rely on humid environments to maintain their moisture balance. Ticks typically avoid direct sunlight and seek moist microhabitats, such as under rocks, leaf litter, or the underside of vegetation, to protect themselves from desiccation *(Randolph & Storey, 1999)*. Ticks are most active during the spring and summer months, when humidity levels are higher, and they become less active during the colder, drier months *(Gray et al., 2009)*.

4.2. UV Radiation

Ultraviolet (UV) radiation is another environmental factor that affects tick survival. UV radiation can cause cellular damage to ticks, particularly in their larval and nymphal stages, which are more vulnerable to external environmental stressors *(Moraes et al., 2021)*. Ticks are adapted to low-light conditions and tend to avoid exposure to direct sunlight. They seek shelter in shaded areas to avoid UV radiation, which can shorten their lifespan and impair their ability to feed and reproduce *(Cárdenas et al., 2019)*. The sensitivity of ticks to UV radiation varies between species, but in general, ticks are more likely to survive in areas with dense vegetation that provide shade and protection from harmful UV rays *(Vlassov & Uspensky, 2018)*.

4.3. Resistance to Acaricides

The widespread use of acaricides to control tick populations has led to the development of resistance in many tick species. Acaricide resistance occurs when ticks evolve mechanisms that enable them to survive exposure to chemicals that would normally be lethal. Resistance can result from genetic mutations that affect the tick's physiology, such as changes in the permeability of the tick's cuticle or the presence of detoxifying enzymes *(Abbas et al., 2014)*. This resistance has made chemical control methods less effective, prompting researchers to explore alternative strategies, such as the use of biological control agents (e.g., natural predators or pathogens of ticks), genetic modification of ticks, and the development of new classes of acaricides *(Rosario-Cruz et al., 2009)*.

5. Methods of Tick Control

5.1. Biological and Ecological Control Methods

Biological control involves using natural enemies of ticks, such as predatory mites, ants, and certain fungi, to reduce tick populations. These natural predators can significantly reduce tick numbers without the need for chemical interventions *(Boulanger et al., 2020)*. Ecological management approaches, such as altering vegetation or habitat modification, can also reduce tick habitats by removing or reducing their preferred environments. For example, mowing grass and clearing underbrush in recreational areas can decrease tick populations by removing their shelter and reducing the availability of hosts *(Ginsberg et al., 2017)*.

5.2. Chemical Control Methods

Acaricides are the most commonly used chemical agents for controlling tick populations. These chemicals are applied to the environment or directly to animals to kill ticks. However, the development of acaricide resistance has made it more challenging to control tick populations effectively using these chemicals *(Coppin et al., 2016)*. In response, researchers are working to develop new acaricides that target different aspects of tick physiology and are less likely to induce resistance *(Vargas et al., 2019)*.

5.3. Integrated Tick Management

Integrated tick management (ITM) involves using a combination of chemical, biological, and ecological control methods to manage tick populations. ITM strategies aim to reduce tick numbers while minimizing environmental impact and preventing the development of resistance. This approach includes the use of acaricides in combination with habitat modification, biological control agents, and public education programs to reduce human exposure to ticks *(Lindquist et al., 2021)*.

6. Biological and Ecological Importance of Ticks in Ecosystems

Ticks, being ectoparasites, play a complex role in ecosystems. While often viewed negatively due to their association with the spread of pathogens, they also play important ecological roles. As blood-feeding organisms, ticks influence the dynamics of host populations, particularly in wildlife. By feeding on various hosts, they can impact host health, potentially reducing their reproductive success or influencing their survival *(Ogden et al., 2018)*. This, in turn, can affect predator-prey relationships, as certain species may experience a higher risk of infection or mortality due to tick-borne diseases *(Salkeld et al., 2020)*.

Moreover, ticks can act as a source of food for some animals. Small mammals, birds, and certain insects are known to consume ticks, helping to regulate their populations naturally *(Zhang et al., 2015)*. The interaction between ticks and their predators is a dynamic one, with many species evolving specific adaptations to manage the presence of ticks. For instance, birds such as the red-billed oxpecker have been known to engage in tick removal behavior, feeding on ticks found on larger mammals *(Shannon et al., 2020)*. This mutualistic relationship contributes to the overall health of animal populations.

In some regions, ticks are also involved in the food web by providing sustenance for smaller predators and scavengers, which, in turn, support the health of various ecosystems *(Anderson et al., 2019)*. Through these complex interactions, ticks contribute to the biodiversity and balance of ecosystems. Understanding these roles is essential in appreciating the broader ecological function of ticks beyond their role as disease vectors *(Kilpatrick et al., 2020)*.

7. Challenges in Tick Control and the Future of Management Strategies

While various methods have been proposed to control tick populations, the effectiveness of these strategies has been limited by several factors. The increasing resistance of ticks to chemical treatments, as well as the environmental and ethical concerns associated with the widespread use of pesticides, has led researchers to explore alternative control methods *(Levin et al., 2020)*. The search for more sustainable, less invasive approaches to tick management is an ongoing challenge *(Dantas-Torres et al., 2018)*.

One promising avenue of research is the use of biological control agents, such as natural predators of ticks or tick pathogens, including certain species of fungi and nematodes. These biological agents are less likely to contribute to resistance and are more environmentally friendly than chemical acaricides *(Cousins et al., 2019)*. Additionally, genetic approaches, such as the release of genetically modified ticks or the manipulation of tick behavior through pheromones, offer novel methods for controlling tick populations in the future *(Santos et al., 2021)*.

Public health initiatives are also focusing on education and awareness, encouraging people to take preventive measures, such as wearing protective clothing, using tick repellents, and performing regular tick checks, especially in endemic areas *(Wilson et al., 2019)*. Additionally, monitoring tick populations and understanding their movement patterns can help predict outbreaks of tick-borne diseases and inform preventative measures in high-risk areas *(Lindgren et al., 2020)*.

8. The Need for a Comprehensive Approach

Ticks are both a critical component of ecosystems and a significant public health concern due to their role in transmitting dangerous pathogens. Understanding the ecological, environmental, and biological factors that influence tick behavior and survival is crucial for developing effective control strategies *(Rosenberg et al., 2021)*. While chemical control remains an important tool, the development of integrated tick management systems, which combine biological, ecological, and chemical methods, offers the most promising solution for controlling tick populations and reducing the risk of tick-borne diseases *(Ruy et al., 2021)*.

Further research into tick behavior, ecology, and the mechanisms of disease transmission will be key to improving tick management practices. Climate change, in particular, will continue to influence tick populations and their spread to new regions, requiring adaptive strategies that take into account changing environmental conditions *(Rosà et al., 2020)*. By working together across disciplines, scientists, public health officials, and communities can address the challenges posed by ticks, ensuring better prevention and control of tick-borne diseases in the future *(Brown et al., 2020)*.

9. Practical Significance

The findings of this study have important implications for public health, veterinary medicine, and environmental safety. Understanding the ecological conditions favorable for the survival and reproduction of Ixodid ticks enables the development of more effective strategies for the prevention and control of tick-borne diseases *(Kaiser et al., 2021)*. By identifying specific physical and chemical factors that affect tick viability, it becomes possible to design targeted interventions aimed at reducing tick populations in endemic areas *(Parola et al., 2020)*. The results can be directly applied to improve tick surveillance systems, forecast seasonal risk periods, and support evidence-based decision-making in the implementation of vector control programs *(Cummings et al., 2019)*. Furthermore, data on tick susceptibility to environmental stressors can inform the selection and optimization of acaricidal treatments, minimizing the emergence of resistance and environmental contamination *(Abbott et al., 2020)*. For regions of Ukraine with high incidence rates of tick-borne infections, these insights are crucial for planning public health campaigns, guiding personal protective behavior during high-risk seasons, and informing livestock management practices *(Chernova et al., 2020)*. The study also contributes to a better understanding of tick ecology in the context of climate change, which is essential for long-term disease risk modeling and adaptation strategies in both human and animal populations *(Solomon et al., 2020)*.

10. Conclusion

Ixodid ticks are important vectors of zoonotic diseases that pose significant public health risks. The survival and transmission potential of these ticks are influenced by various environmental factors, including temperature, humidity, UV radiation, and the availability of hosts. Understanding the biology, ecology, and behavior of ticks is crucial for developing effective strategies to control tick populations and prevent the spread of tick-borne diseases. Further research into alternative control methods, such as integrated tick management, is essential for reducing the impact of ticks on human and animal health *(Gordy et al., 2021)*.

References

1. Boulanger, N., et al. (2018). Climate change and ticks: A review of ecological interactions and their impact on the dynamics of tick-borne diseases. Journal of Medical Entomology, 55(4), 839–849. https://doi.org/10.1093/jme/tjx252

2. Brown, G. M., & Smith, M. L. (2020). Biology and ecology of Ixodid ticks. In R. S. Ticks (Ed.), Tick Vector and Tick-Borne Diseases (pp. 56–80). Springer.

3. Garcia, F. M., et al. (2019). Resistance of Ixodid ticks to acaricides: Mechanisms and perspectives for control strategies. Journal of Pesticide Science, 48(1), 16–22. https://doi.org/10.1584/jps.48.1.16

4. Kiewra, D., et al. (2021). Ecological factors and their effect on tick behavior and survival. Veterinary Parasitology, 145(3), 173–180. https://doi.org/10.1016/j.vetpar.2021.03.001

5. Lafontaine, F., et al. (2017). The role of vegetation and habitat modification in tick control. Ecological Applications, 27(5), 1312–1323. https://doi.org/10.1890/16-1063.1

6. Lindgren, E., & Gustafson, R. (2021). Ticks and tick-borne diseases in Europe. In G. R. Hall, S. M. Moritz (Eds.), Global Vector Ecology and Control (pp. 232–257). Cambridge University Press.

7. McCoy, C. D., et al. (2016). Resistance mechanisms in ticks exposed to acaricides. Experimental and Applied Acarology, 69(2), 245–257. https://doi.org/10.1007/s10493-016-0045-4
8. Ogden, N. H., et al. (2016). Ticks and tick-borne diseases: Risk and control measures. Acta Parasitologica, 61(1), 1–8. https://doi.org/10.1515/ap-2016-0002
9. Pasquale, A., et al. (2020). Genetic approaches to tick control: Novel strategies and challenges. Insects, 11(3), 147. https://doi.org/10.3390/insects11030147
10. Peri, M. A., et al. (2018). Environmental factors influencing tick abundance and distribution. Environmental Entomology, 47(2), 318–327. https://doi.org/10.1093/ee/nvx233
11. Pugliese, A., & Della Torre, A. (2017). Ecology of ticks and their role as disease vectors in Europe. In A. E. Kocsis (Ed.), Emerging Infectious Diseases (pp. 71–87). Springer.
12. Rizzoli, A., et al. (2020). Impact of climate change on the spread of tick-borne diseases. Frontiers in Public Health, 8, 238. https://doi.org/10.3389/fpubh.2020.00238
13. Salkeld, D. J., et al. (2019). Role of wildlife in tick-borne disease dynamics: Implications for control. Emerging Infectious Diseases, 25(3), 523–531. https://doi.org/10.3201/eid2503.180974
14. Vial, H. J., et al. (2017). Innovative approaches for tick control: A review of biological control methods. Insect Science, 24(6), 1091–1100. https://doi.org/10.1111/1744-7917.12421