

REPVIAS

RESEARCH & PRACTICE in VETERINARY & ANIMAL SCIENCE

Volume: 3 Issue: 2 Year: 2026

e-ISSN: 3023-6681



RESEARCH & PRACTICE in VETERINARY & ANIMAL SCIENCE

Volume: 3, Issue: 2 (July 2026)

International Peer Reviewed Journal

Owner

Necmettin Erbakan University

Editor-in-Chief

Prof. Dr. Nuri ALTUĞ

Necmettin Erbakan University, Faculty of Veterinary Medicine,
Ereğli, Konya, Türkiye

Publication Type

Periodical

Publication Period

Published twice-annual (January and July)

Print Date

July 2026

Correspondence Address

Necmettin Erbakan University, Faculty of Veterinary Medicine,
Orhaniye Quarter University Street No:15, Ereğli, Konya, Türkiye

Phone: 90 332 777 00 66 / 7231

Web: <https://www.repvas.com>

E-mail: repvas@erbakan.edu.tr

Research & Practice in Veterinary & Animal Science is an international peer reviewed twice-annual journal

ISSN: 3023-6681

PUBLISHING BOARD

Chairman

Prof. Dr. Nuri ALTUĞ

Necmettin Erbakan University, Faculty of Veterinary Medicine,

Ereğli, Konya, Türkiye

nurialtug@erbakan.edu.tr

ORCID: 0000-0001-5805-0340

Members

Prof. Dr. Yıldırım BAŞBUĞAN

Yüzüncü Yıl University, Faculty of Veterinary Medicine,

Van, Türkiye

yildirimbasbugan@gmail.com

ORCID: 0000-0001-5124-7853

Prof. Dr. Hidayet Metin ERDOĞAN

Aksaray University, Faculty of Veterinary Medicine,

Aksaray, Türkiye

hmerdogan@aksaray.edu.tr

ORCID: 0000-0003-1261-4352

Assoc. Prof. Dr. Ruhi KABAKÇI

Kırıkkale University, Faculty of Veterinary Medicine,

Kırıkkale, Türkiye

ruhikabakci@kku.edu.tr

ORCID: 0000-0001-9131-0933

Prof. Dr. Cengiz YILDIZ

Yalova University, Faculty of Medicine, Türkiye

cengiz.yildiz@yalova.edu.tr

ORCID: 0000-0002-9166-8836

EDITORIAL BOARDS

Editors-in-Chief

Prof. Dr. Nuri ALTUĞ
Necmettin Erbakan University, Faculty of Veterinary Medicine, Ereğli,
Konya, Türkiye
nurialtug@erbakan.edu.tr ORCID: 0000-0001-5805-0340

Associate Editors-in-Chief

Assoc. Prof. Dr. Ruhi KABAKÇI, Kırıkkale University, Faculty of Veterinary Medicine,
Kırıkkale, Türkiye
ruhikabakci@kku.edu.tr ORCID: 0000-0001-9131-0933

Assist. Prof. Dr. Hasan Hüseyin ŞENYÜZ
Necmettin Erbakan University, Faculty of Veterinary Medicine, Ereğli, Konya, Türkiye
hasansenyuzvet@yahoo.com ORCID: 0000-0002-3695-1794

Language Editors

Prof. Dr. Hidayet Metin ERDOĞAN, Aksaray University, Faculty of Veterinary Medicine,
Aksaray, Türkiye
hmerdogan@aksaray.edu.tr ORCID: 0000-0003-1261-4352

Assoc. Prof. Dr. Ruhi KABAKÇI, Kırıkkale University, Faculty of Veterinary Medicine,
Kırıkkale, Türkiye
ruhikabakci@kku.edu.tr ORCID: 0000-0001-9131-0933

Prof. Dr. Cengiz YILDIZ, Yalova University, Faculty of Medicine, Yalova, Türkiye
cengiz.yildiz@yalova.edu.tr ORCID: 0000-0002-9166-8836

Biostatistics Editors

Prof. Dr. Mehmet Emin TEKİN, Selçuk University, Faculty of Veterinary Medicine, Konya, Türkiye
mtekin@selcuk.edu.tr ORCID: 0000-0002-3449-9984

Prof. Dr. Serkan ERAT, Kırıkkale University, Faculty of Veterinary Medicine, Kırıkkale, Türkiye
serkanerat@yahoo.com ORCID: 0000-0002-9549-8694

Asist. Prof. Dr. Harun YONAR, Selçuk University, Faculty of Veterinary Medicine, Konya, Türkiye
hyonar@selcuk.edu.tr ORCID: 0000-0003-1574-3993

Assist. Prof. Dr. Muhammet Hanifi SELVİ
Necmettin Erbakan University, Faculty of Veterinary Medicine, Ereğli, Konya, Türkiye
mselvi@erbakan.edu.tr ORCID: 0000-0002-9785-9174

Spelling Editor

Prof. Dr. Yıldırım BAŞBUĞAN, Yüzüncü Yıl University, Faculty of Veterinary Medicine,
Van, Türkiye
yildiraybasbugan@gmail.com ORCID: 0000-0001-5124-7853

Layout/Typesetting Editors

Prof. Dr. Mustafa YİPEL, Mustafa Kemal University, Türkiye
Assist. Prof. Dr. Neffel Kürşat AKBULUT, Necmettin Erbakan University, Türkiye
Assist. Prof. Dr. Ayşe SARI, Necmettin Erbakan University, Türkiye
Research Assistant Ramazan AYAŞ, Necmettin Erbakan University, Türkiye
Research Assistant Hamza Yavuz Selim CAN, Necmettin Erbakan University, Türkiye
Research Assistant Muhammed Can GÖKMEN, Necmettin Erbakan University, Türkiye
Research Assistant Muhammet Mücahid SARI, Necmettin Erbakan University, Türkiye
Bünyamin BİÇER, Necmettin Erbakan University, Türkiye

SECTION EDITORS**Prof. Dr. Süleyman ALEMDAR**

Sivas Cumhuriyet University, Faculty of Veterinary Medicine, Sivas, Türkiye
salemdar@cumhuriyet.edu.tr
ORCID: 0000-0002-5119-0719

Prof. Dr. Muhammed Enes ALTUĞ

Hatay Mustafa Kemal University, Faculty of Veterinary Medicine, Hatay, Türkiye
ealtug@mku.edu.tr
ORCID: 0000-0003-3896-9944

Assoc. Prof. Dr. Serkan ATEŞ

Oregon State University, College of Agricultural Sciences, Oregon, USA
serkan.ates@oregonstate.edu
ORCID: 0000-0001-6825-3248

Prof. Dr. Halil Selçuk BİRİCİK

Afyon Kocatepe University, Faculty of Veterinary Medicine, Afyonkarahisar, Türkiye
hsbiricik@aku.edu.tr
ORCID: 0000-0003-4974-1611

Prof. Dr. Abdul Shakoore CHAUDHRY

Newcastle University, Agriculture Building, Newcastle, UK
abdul.chaudhry@newcastle.ac.uk
ORCID: 0000-0002-6350-0374

Prof. Dr. Emrullah EKEN

Selçuk University, Faculty of Veterinary Medicine, Konya, Türkiye
eeken@selcuk.edu.tr
ORCID: 0000-0001-7426-5325

Prof. Dr. Serkan ERAT

Kırıkkale University, Faculty of Veterinary Medicine, Kırıkkale, Türkiye
serkanerat@yahoo.com
ORCID: 0000-0002-9549-8694

Prof. Dr. Meryem Çınar EREN

Erciyes University, Faculty of Veterinary Medicine, Kayseri, Türkiye
meren@erciyes.edu.tr
ORCID: 0000-0003-1339-0493

Prof. Dr. Ramazan GÖNENCİ

Necmettin Erbakan University, Faculty of Veterinary Medicine,
Ereğli, Konya, Türkiye
rgonenci@erbakan.edu.tr
ORCID: 0000-0002-4043-2612

Prof. Dr. Ziya İLHAN

Balıkesir University, Faculty of Veterinary Medicine, Balıkesir, Türkiye
zilhan@balikesir.edu.tr
ORCID: 0000-0003-3638-9196

Prof. Dr. Tahir KARAŞAHİN

Aksaray University, Faculty of Veterinary Medicine, Aksaray, Türkiye
tahirkarasahin@aksaray.edu.tr
ORCID: 0000-0003-2358-0389

Prof. Dr. Mehmet Akif KARSLI

Kırıkkale University, Faculty of Veterinary Medicine, Kırıkkale, Türkiye
mehmetakifkarsli@hotmail.com
ORCID: 0000-0002-3081-9450

Prof. Dr. Muhamed KATICA

Sarajevo University, Faculty of Veterinary Medicine,
Sarajevo, Bosnia and Herzegovina
muhamed.katica@vfs.unsa.ba
ORCID: 0000-0002-8184-0065

Prof. Dr. Ertan ORUÇ

Selçuk University, Faculty of Veterinary Medicine, Konya, Türkiye
ertanoruc@selcuk.edu.tr
ORCID: 0000-0003-1964-0238

Prof. Dr. Dariusz PIWCZYNSKI

University of Science and Technology,
Faculty of Animal Breeding and Biology, Bydgoszcz, Poland
darekp@pbs.edu.pl
ORCID: 0000-0001-8298-2316

Asist. Prof. Dr. Abdur RAHMAN

University of Veterinary and Animal Sciences,
Department of Animal Sciences, Punjab, Pakistan
abdurrehman@uvas.edu.pk
ORCID: 0000-0002-3440-8106

Prof. Dr. Emrah SUR

Selçuk University, Faculty of Veterinary Medicine, Konya, Türkiye
emrahsur@selcuk.edu.tr
ORCID: 0000 0002 3513 7424

Prof. Dr. Atilla ŞİMŞEK

Selçuk University, Faculty of Veterinary Medicine, Konya, Türkiye
asimsek@selcuk.edu.tr
ORCID: 0000-0001-5117-501X

Prof. Dr. İbrahim TAŞAL

Mehmet Akif Ersoy University, Faculty of Veterinary Medicine, Burdur, Türkiye
ibrahimtasal@mehmetakif.edu.tr
ORCID: 0000-0003-4632-3115

Prof. Dr. Mehmet YAMAN

Hatay Mustafa Kemal University, Faculty of Veterinary Medicine, Hatay, Türkiye
mehmetyaman21@hotmail.com
ORCID ID0000-0001-5399-8060

Prof. Dr. Nazmi YÜKSEK

Van Yüzüncü Yıl University, Faculty of Veterinary Medicine, Van, Türkiye
nyuksekk@yyu.edu.tr
ORCID: 0000-0003-4613-9334

ADVISORY BOARDS**Prof. Dr. Ali AKMAZ**

Selçuk University, Retired Lecturer, Konya, Türkiye
profaliakmaz@gmail.com
ORCID: 0000-0002-1088-9937

Prof. Dr. Ali ERTEKİN

Samsun Ondokuz Mayıs University, Samsun, Türkiye
aertekin@omu.edu.tr
ORCID: 0000-0002-6299-9716

Prof. Dr. İhsan KELEŞ

Erciyes University, Kayseri, Türkiye
ihsankeles@yahoo.com
ORCID: 0000-0001-5751-9450

Prof. Dr. Ender YARSAN

Ankara University, Ankara, Türkiye
yarsan@veterinary.ankara.edu.tr
ORCID: 0000-0002-3008-9240

REVIEWER LIST of VOLUME 3 (2026)

Prof. Dr. Mehmet Faruk AYDIN

Balıkesir University, Faculty of Veterinary Medicine, Department of Histology,
Balıkesir, Türkiye

Prof. Dr. Yıldırım BAŞBUĞAN

Yüzüncü Yıl University, Faculty of Veterinary Medicine, Department of Veterinary Internal
Medicine, Van, Türkiye

Prof. Dr. Ahmet ÇAKIR

Ankara University, Faculty of Veterinary Medicine, Department of Anatomy,
Ankara, Türkiye

Prof. Dr. Yasin DEMİRASLAN

Dokuz Eylül University, Faculty of Veterinary Medicine, Department of Anatomy,
İzmir, Türkiye

Prof. Dr. Önder DÜZLÜ

Erciyes University, Faculty of Veterinary Medicine, Department of Parasitology,
Kayseri, Türkiye

Prof. Dr. Mukadderat GÖKMEN

Aksaray University, Faculty of Veterinary Medicine, Department of Food Hygiene and
Technology
Aksaray, Türkiye

Prof. Dr. Nuri MAMAK

Burdur Mehmet Akif Ersoy University, Faculty of Veterinary Medicine, Department of
Veterinary Internal Medicine,
Burdur, Türkiye

Prof. Dr. Seyithan SEYDOŞOĞLU

Siirt University, Faculty of Agriculture, Department of Field Crops,
Siirt, Türkiye

Prof. Dr. Mehmet TUZCU

Selçuk University, Faculty of Veterinary Medicine, Department of Pathology,
Konya, Türkiye

Prof. Dr. Uğur USLU

İstanbul Medeniyet University, Faculty of Medicine, Department of Parasitology,
İstanbul, Türkiye

Assoc Prof. Dr. Gökhan AKÇAKAVAK

Aksaray University, Faculty of Veterinary Medicine, Department of Pathology,
Aksaray, Türkiye

Assoc Prof. Dr. Enes AKYÜZ

Kafkas University, Faculty of Veterinary Medicine, Department of Veterinary Internal Medicine,
Kars, Türkiye

Assoc Prof. Dr. Fulya ALTINOK YİPEL

Necmettin Erbakan University, Faculty of Veterinary Medicine, Department of Veterinary
Internal Medicine,
Konya, Türkiye

Assoc. Prof. Dr. Sedat AYDOĞDU

Selcuk University, Faculty of Veterinary Medicine, Department of Anatomy,
Konya, Türkiye

Assoc Prof. Dr. Cemalettin AYVAZOĞLU

Ardahan University, Göle Vocational School,
Ardahan, Türkiye

Assoc. Prof. Dr. Ayşe Ebru BORUM

Balıkesir University, Faculty of Veterinary Medicine, Department of Microbiology,
Balıkesir, Türkiye

Assoc. Prof. Dr. Metehan KUTLU

Necmettin Erbakan University,, Faculty of Veterinary Medicine, Department of Obstetrics and
Gynecology,
Konya, Türkiye

Assoc. Prof. Dr. Mahir ÖZKURT

Muş Alparslan University, Faculty of Applied Sciences, Crop Production,
Muş, Türkiye

Assoc. Prof. Dr. Seyda ŞAHİN

Sivas Cumhuriyet University, Faculty of Veterinary Medicine, Department of Food Hygiene and
Technology,
Sivas, Türkiye

Assoc. Prof. Dr. Arife Ezgi TELLİ

Selçuk University, Faculty of Veterinary Medicine, Department of Food Hygiene and Technology,
Konya, Türkiye

Assoc Prof. Dr. Orhan YAVUZ

Dokuz Eylül University, Faculty of Kiraz Veterinary Medicine, Department of Pathology,
İzmir, Türkiye

Assistant Prof. Dr. Özlem HACAN

Afyon Kocatepe University, Faculty of Veterinary Medicine, Department of Zootechnics,
Afyonkarahisar, Türkiye

Assistant Prof. Dr. Feyyaz KAYA

Balıkesir University, Faculty of Veterinary Medicine, Department of Internal Diseases,
Balıkesir, Türkiye

Assistant Prof. Dr. Muhammet Hanifi SELVİ

Necmettin Erbakan University, Faculty of Veterinary Medicine, Department of Zootechnics,
Konya, Türkiye

Assistant Prof. Dr. Hasan Hüseyin ŞENYÜZ

Necmettin Erbakan University, Faculty of Veterinary Medicine, Department of Animal Nutrition
and Nutritional Diseases,
Konya, Türkiye

Assistant Prof. Dr. Soner UYSAL

Atatürk University, Faculty of Veterinary Medicine, Department of Animal Nutrition and
Nutritional Diseases,
Erzurum, Türkiye

Asist. Prof. Dr. Harun YONAR

Selçuk University, Faculty of Veterinary Medicine,
Konya, Türkiye

Dr. Afşin KOCAKAYA

Ankara University, Faculty of Veterinary Medicine, Department of Zootechnics,
Ankara, Türkiye

Contents

Research Article

Title of the article Author(s)	Page
Canine Distemper: A Bibliometric Analysis of Global Research Trends (1980-2024) <i>Furkan Çağrı BEŞOLUK, Harun YONAR</i>	67-78
Prevalence and Significance of Gastrointestinal Parasites in Turkeys (Meleagris gallopavo) in Konya <i>Burak ÇELİK, Ayşe EVÇİ, Bengi Su ŞAHİN, Ahmet Can KAYA, Nermin IŞIK USLU</i>	79-87
Nutrient digestibility of Red Sokoto Goats During the Dry Hot Season of Derived Savanna Zone of Nigeria <i>Ayobami Isaiah ADEDEJI</i>	88-94
Sea Water Enhances Formalin Fixation of Sheep Tissues: Comparative Study with Distilled Water <i>Esin ÜNSALDI</i>	95-107
An Exploratory Observational Study of Rearing Behaviour in Horses <i>Yavuzkan PAKSOY, Ömer Barış İNCE, Nazan KOLUMAN</i>	108-115

Canine Distemper: A Bibliometric Analysis of Global Research Trends (1980-2024)

Furkan Çağrı BEŞOLUK ^{*}, Harun YONAR 

Selcuk University, Faculty of Veterinary Medicine, Department of Biostatistics, Konya, 42130, Türkiye

Article Info

ABSTRACT

Received: 31.10.2025

Accepted: 10.03.2026

Online first: 21.07.2026

Published: 27.07.2026

Keywords:

Bibliometric analysis,
Canine distemper virus,
CDV,
Morbillivirus,
Scientific mapping.

Canine distemper virus (CDV) is a significant infectious disease affecting domestic dogs and wild carnivores worldwide. However, there is a lack of systematic, quantitative assessments of this topic in the literature. This bibliometric analysis examined 2,842 publications from the Web of Science Core Collection spanning 45 years (1980–2024), evaluating research trends, geographical distribution by country and institution, and author collaboration networks in canine distemper studies. The analysis revealed distinct temporal phases in publication patterns, characterised by modest output during the foundation period (approximately 20 articles per year from 1980 to 1990), gradual acceleration coinciding with the adoption of PCR technology (mid-1990s to 2005), and exponential growth driven by advances in molecular diagnostics (2005–2015, reaching over 140 articles per year). A recent stabilization suggests that the field is maturing (2020–2024, approximately 115 articles per year). A geographic analysis revealed a regional concentration of research, with the United States dominating with 2,281 publications (38%). This was followed by China with 660 publications (11%) and Germany with 581 publications (10%). This reflects the importance of a well-established research infrastructure, as well as disparities in availability. Institutions such as the University of Bern (201 publications), the University of California system (186) and the University of Veterinary Medicine Hannover (164) consistently showcased their research. Author impact analysis identified Zurbriggen A. and Vandeveld M. as the most influential researchers, with a high citation impact (h-index of 33 for both) and high productivity (84 and 64 publications respectively). Keyword co-occurrence analysis revealed four distinct thematic clusters: molecular epidemiology and phylogenetics; wildlife conservation and interspecies transmission; clinical pathology and neurological manifestations; and diagnostic methodologies. This study provides a comprehensive, quantitative assessment of canine distemper research, identifying key contributors to veterinary medicine and wildlife conservation, as well as collaborative networks, knowledge gaps and future research priorities.

To cite this article:

Beşoluk, F. Ç., Yonar, H. (2026). Canine Distemper: A Bibliometric Analysis of Global Research Trends (1980-2024), *Research and Practice in Veterinary and Animal Science (REPVAS)*, 3(2), 67-78.
<https://doi.org/10.69990/REPVAS.2026.3.2.1>

***Corresponding Author:** Furkan Çağrı Beşoluk, furkan.besoluk@selcuk.edu.tr

INTRODUCTION

Canine distemper virus (CDV), a highly contagious Morbillivirus belonging to the Paramyxoviridae family, causes multisystemic disease in domestic dogs and wild carnivores worldwide (Appel & Summers, 1995; Martella et al., 2008). Despite effective vaccines having been available against this virus since the 1960s, CDV continues to pose a significant threat, particularly in areas with inadequate vaccination coverage (Beineke et al., 2015). Outbreaks of CDV in endangered species, including African wild dogs, Amur tigers and whales, have emerged as a significant threat to wildlife conservation (Deem et al., 2000; Seimon et al., 2013). The detection of CDV in uncommon hosts, including non-human primates, raises concerns about potential zoonotic impacts (Qiu et al., 2011).

Over the past four decades, the scientific literature on canine distemper has expanded significantly, driven by increased investment in research and a growing recognition of the disease's complex epidemiological dynamics. Bibliometric analysis provides a systematic, quantitative approach to evaluating the structure, evolution and trends within research fields, employing various metrics and indicators (Donthu et al., 2021; Moral-Muñoz et al., 2020). This methodology enables the identification of influential publications, productive authors and institutions, collaboration networks and emerging themes. Such analyses have proven valuable in veterinary medicine and infectious disease research, providing insight into research trajectories (Uzabaci et al., 2025; Elasan and Sahin, 2025).

This research conducts a comprehensive bibliometric analysis to uncover key publication trends, influential entities (authors/institutions), and international collaboration networks in the field, utilizing keyword co-occurrence patterns to map and delineate emerging research frontiers. This study aims to inform researchers and veterinarians about the landscape and development of canine distemper research.

MATERIAL and METHODS

Data Source and Search Strategy

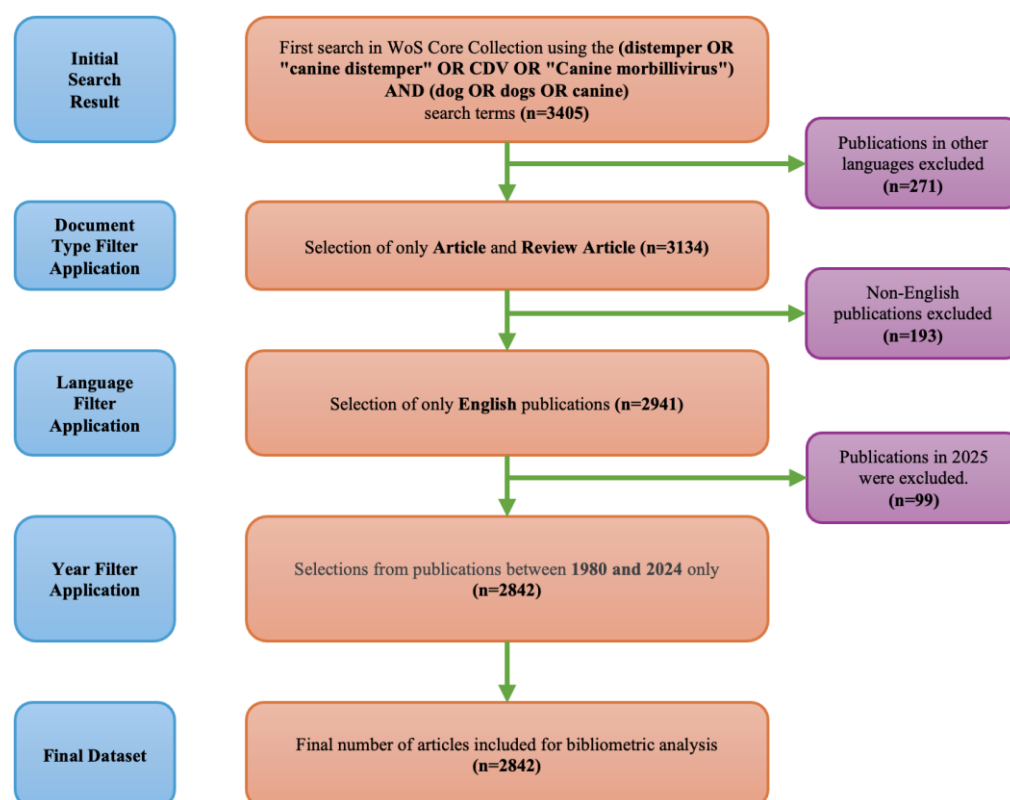
A comprehensive literature search was conducted using the Web of Science Core Collection (WoSCC) on September 20, 2025. WoSCC was chosen for its comprehensive coverage of peer-reviewed publications, comprehensive citation indexing, and standard format for reliable bibliometric analyses (Pranckutė, 2021).

The search query used in the topic field was (distemper OR "canine distemper" OR CDV OR "canine morbillivirus") AND (dog OR dogs OR canine), resulting in 3,405 publications.

Inclusion and Exclusion Criteria

Specific criteria were applied sequentially. First, the dataset was reduced to 3,134 publications by limiting document types to original research articles and review articles. Secondly, to ensure consistency, only English-language publications were included, resulting in 2,941 publications. Finally, the temporal scope of the publications was limited to the period 1980–2024, leaving 2,842 publications on which the analysis is based (Figure 1).

Figure 1. Data selection flowchart



Data Extraction and Processing

Bibliographic records were exported from WoSCC in plain text format, along with full records and cited references. The exported data included publication titles, author information, abstracts, keywords, publication year, journal information, and citation counts.

Bibliometric Analysis Methods

The performance analysis assessed indicators such as annual publication output and citation metrics (including the h-index, Hirsch, 2005), as well as identifying productive countries, institutions, authors and journals. Scientific mapping methods were used to visualise the intellectual structure and knowledge networks, including co-authorship analysis to identify collaboration patterns, co-citation analysis, and keyword co-occurrence analysis to identify major research themes and their temporal evolution.

Analytical Tools

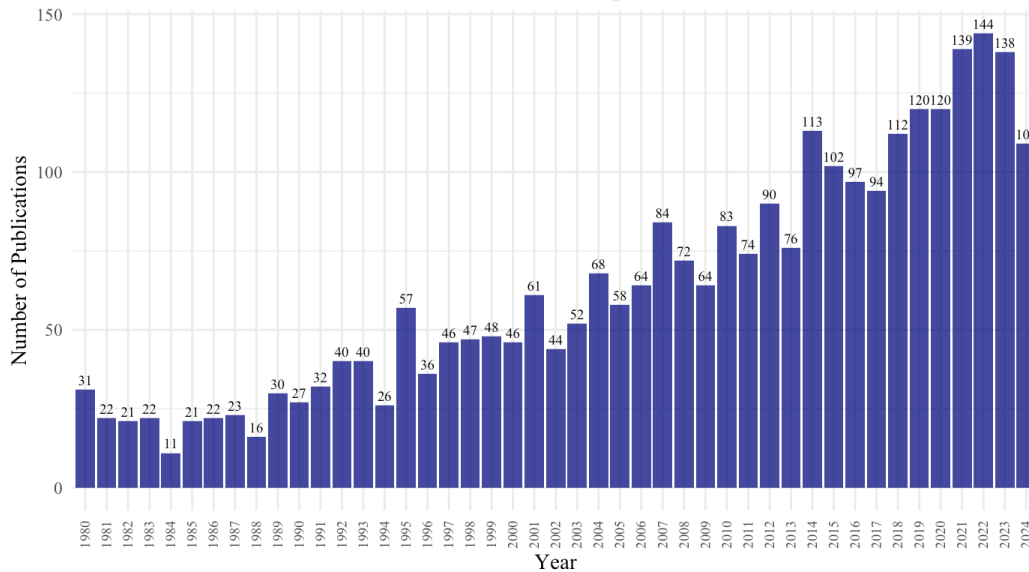
Statistical analyses, including bibliometric index calculations, temporal trend analyses (Aria and Cuccurullo, 2017), were performed using the Bibliometrix R package (version 4.1) within the R statistical environment. The ggplot2 (Wickham, 2016) package was also used for visualization. Network visualizations and keyword co-occurrence maps were created within the Bibliometrix framework.

RESULTS

Temporal Trends in Publication Output

Figure 2 illustrates the annual scientific output from 1980 to 2024. The first period (1980–1990) showed modest output of fewer than 20 articles per year. A gradual acceleration began in the mid-1990s. By 2005, output had reached around 70 articles per year. The most significant growth occurred during the period from 2005 to 2015 (an increase of over 75%), when annual output increased from 80 to over 140 articles. At its peak (2015–2020), output stood at around 135 articles per year. In recent years (2020–2024), the number of articles per year has stabilized at around 115.

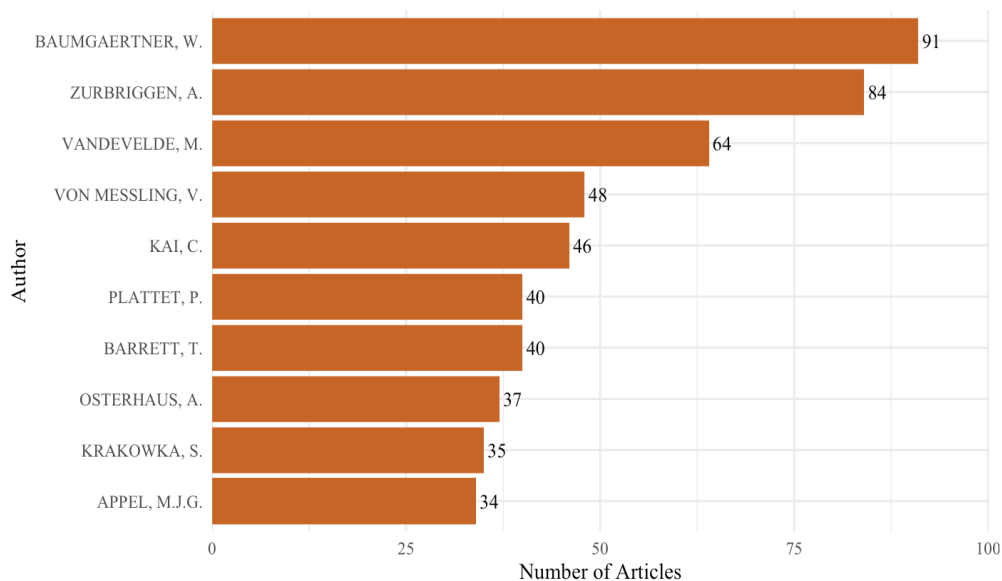
Figure 2. Annual publication output (1980-2024)



Most Productive Authors

Figure 3 shows the top 10 authors with the most publications on this topic, based on their number of publications. Baumgärtner W. leads with approximately 91 publications, followed by Zurbriggen A. and Vandevelde M. (84-64 publications).

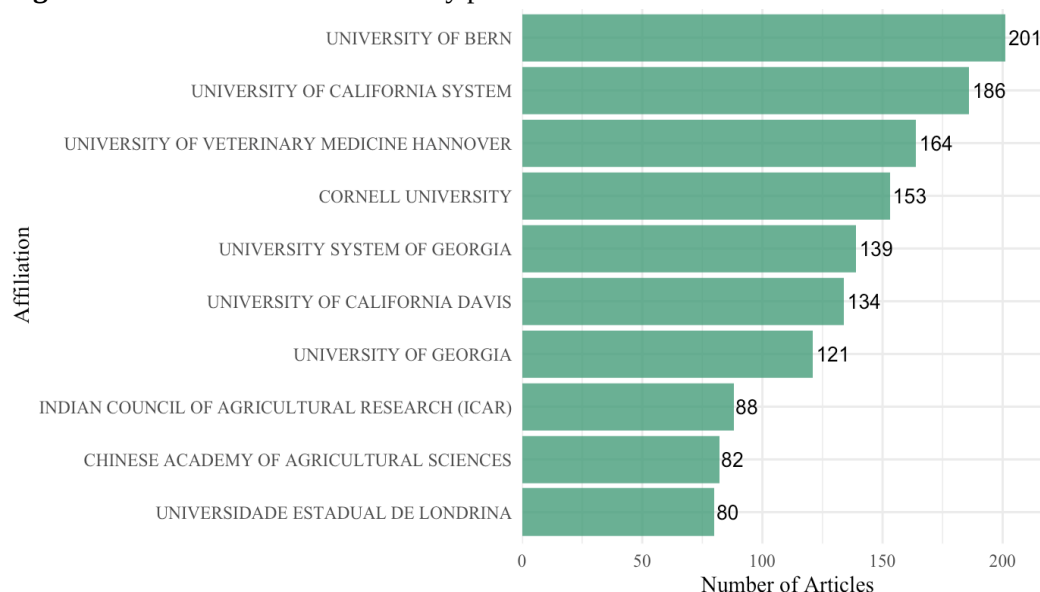
Figure 3. Most productive authors by publication count



Leading Institutions

Figure 4 shows the top 10 institutions ranked by publication frequency. The University of Bern is in first place with around 201 publications. Second place goes to the University of California System with 186 publications. Hannover University of Veterinary Medicine follows with 164 publications. Cornell University and the University of Georgia System complete the top five with 153 and 139 publications, respectively. The presence of specialised veterinary universities and government institutions emphasises the importance of sustained institutional support for productive research programs.

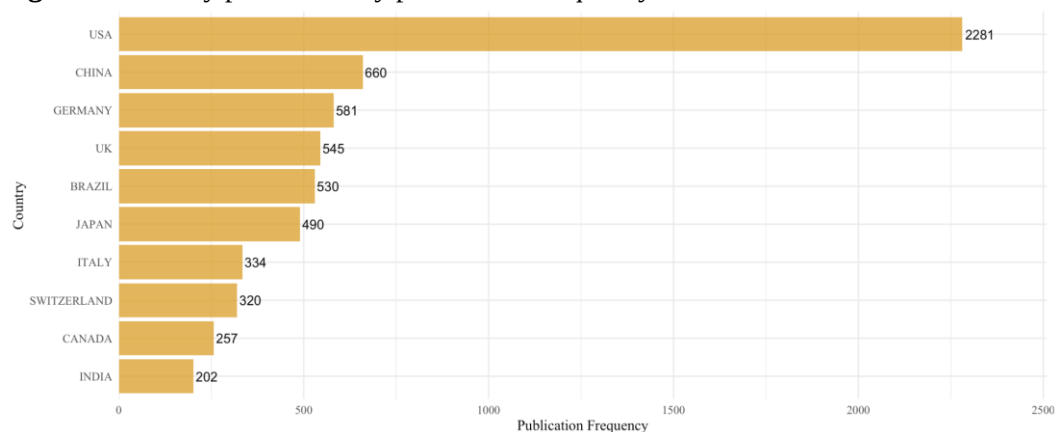
Figure 4. Most relevant affiliations by publication count



Country-Level Production

Figure 5 shows the top 10 countries ranked by the frequency of publications related to CDV. The United States is first with 2,281 publications, followed by China with 660. Germany is third with 581 publications, and the United Kingdom is fourth with 545 publications. Brazil (530 publications), Japan (490 publications), Italy (334 publications), Switzerland (320 publications), Canada (257 publications), and India (202 publications) round out the top ten.

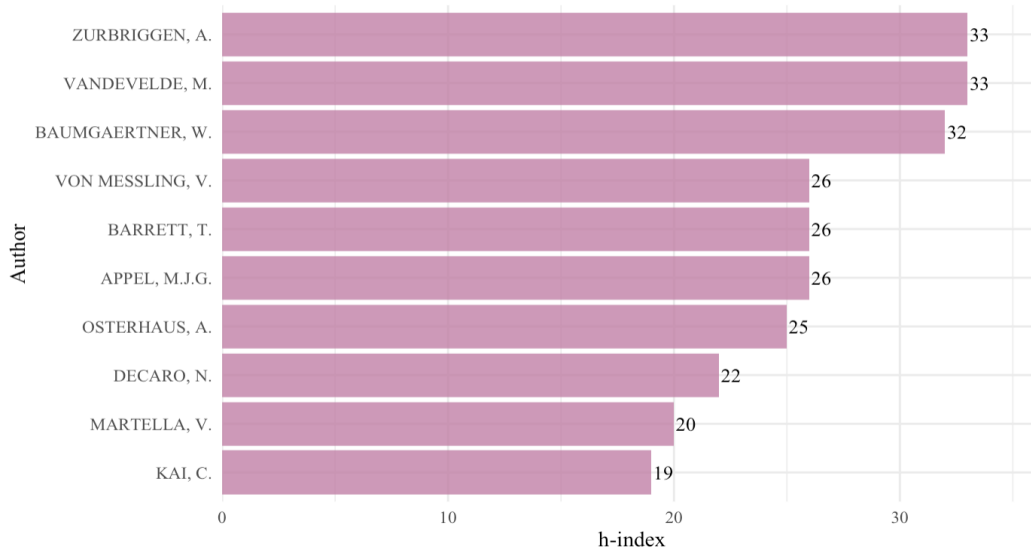
Figure 5. Country production by publication frequency



Author Impact Analysis

Figure 6 shows the h-index rankings of the authors, which measure both their productivity and the impact of their citations. Zurbriggen A. and Vandeveld M. have the highest h-index (33), meaning that each of their articles has received at least 33 citations. Baumgärtner W. (h-index = 32) and Barrett T., Von Messling V., Appel M.J.G. (h-index = 24) follow the rankings with an h-index. This figure illustrates the presence of multiple influential researchers who have achieved significant citation recognition.

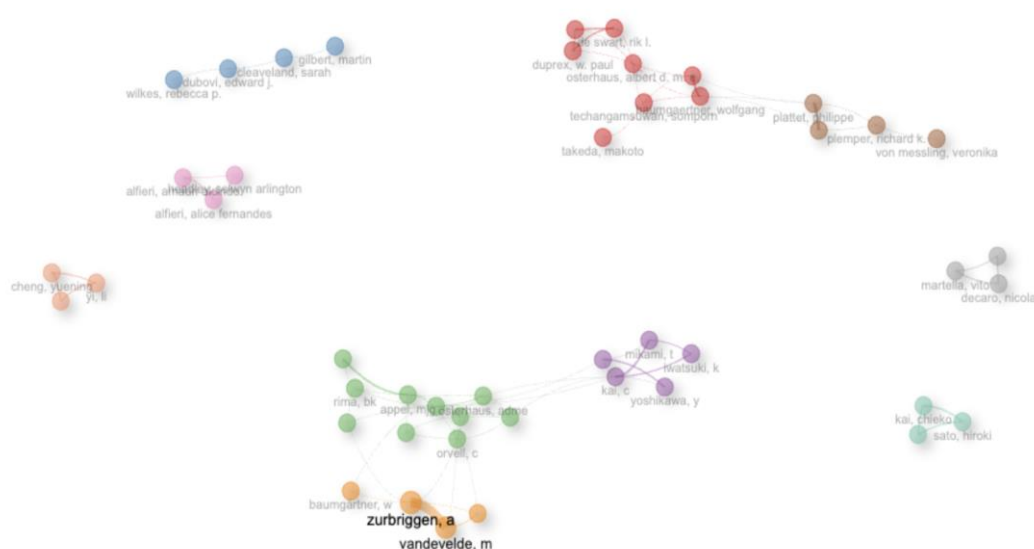
Figure 6. Author impact measured by h-index



Author Collaboration Network

Figure 7 illustrates the collaboration networks of authors working on this topic. The network tends to be clustered. Nodes represent authors and edges represent co-authored publications. Zurbriggen A. and Vandeveld M. occupy central positions within the network, with strong connections to many other authors. Clusters with high connectivity, including authors such as Dubovi E., Gilbert M. and Swart R. I. K., suggest that these researchers collaborate frequently and are involved in specific research topics. Other clusters have more limited connections and represent specific research groups or topics. Some authors, such as Decaro N. and Martella V., appear as more peripheral nodes in the network, suggesting that they collaborate less frequently or are involved in more independent research groups than other authors.

Figure 7. Author collaboration network



Keyword Co-occurrence Network

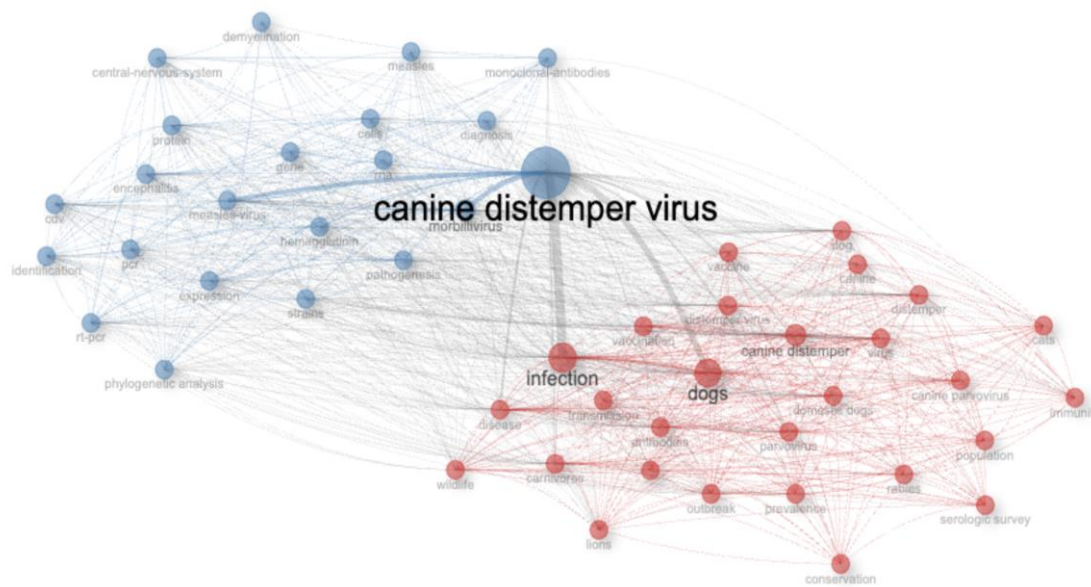
Figure 8 shows the co-occurrence of keywords related to the topic, where nodes represent keywords and edges represent their co-occurrence in documents. The largest and most central cluster contains key terminology such as "canine distemper virus," "infection," and "dogs."

The blue cluster represents a molecular cluster containing keywords such as "morbillivirus," "phylogenetic analysis," "genetic diversity," and "nucleotide sequence." This cluster highlights the importance of molecular epidemiology and genome characterization. Terms such as "encephalitis," "demyelination," "pathology," and "brain" form a clinical subcluster reflecting research on the neurological manifestations of the virus.

The red cluster contains a wildlife cluster containing keywords such as "wildlife," "wild carnivores," "ferrets," and "mink," reflecting the growing recognition of the disease's impact on wildlife conservation and research. There is also an epidemiological subcluster containing terms such as "prevalence," "PCR," "antibodies," and "serology," highlighting diagnostic and surveillance studies in this area.

Overall, this network shows that vaccine-related keywords are linked to both clinical and molecular clusters. The moderate size of the vaccine nodes suggests that the topic is current and that there is still potential for expanding vaccine research.

Figure 8. Keyword co-occurrence network revealing research themes



Word Cloud Visualization

Figure 9 presents a word cloud where word size reflects the frequency of the documents. As expected, the terms "canine distemper virus" and "CDV" are the most prominent, with the largest size. The large size of the terms "dog" and "dogs" suggests that domestic dogs remain the primary focus of research despite the spread of the disease to wildlife. The significant representation of the terms "infection," "morbillivirus," and "disease" confirms that the topic is an infectious disease. Molecular terms such as "PCR," "phylogenetic analysis," and "gene" have significant size, highlighting a strong molecular biology component. Clinical terms such as "encephalitis" and "brain" also show a notable presence. Wildlife terms such as "wildlife carnivores" and "wildlife" have moderate importance. Vaccine-related terms such as "vaccination" are moderately significant. This suggests that vaccination is an active, but not dominant, theme in the studies.

DISCUSSION

This bibliometric analysis of 2,842 publications spanning 45 years reveals the evolution of themes in canine distemper research and its current state. The findings demonstrate phases, geographic concentrations and thematic shifts that reflect technological advances and changing research priorities. Publication rates increased between 2005 and 2015, which coincided with the adoption of molecular diagnostic and sequencing technologies that transformed canine distemper virus (CDV) research from classical virology to genomic epidemiology (Shin et al., 2004; Panzera et al., 2015; Riley and Wilkes, 2015). The recent stabilisation at around 115 publications per year indicates the field's maturity, though research continues. Recent fluctuations may be attributed to the impact of the COVID-19 pandemic on veterinary education and research infrastructure (Mahdy, 2020), as the pandemic broadly disrupted academic publication dynamics across scientific disciplines (Lawson et al., 2025). A geographic analysis revealed a significant concentration of research, with the United States (38% of publications), China (11%) and Germany (10%) dominating global output. This indicates that countries with high incomes and established infrastructure are leading the way in scientific research, reflecting inequalities in research capacity and funding (Christopher and Marusic, 2013; Petersen, 2021). China's strong position indicates substantial

capacity growth in recent years, whereas emerging economies such as Brazil and India demonstrate growing yet limited research participation. Enhanced global collaboration, particularly through North–South partnerships, could address these inequalities and strengthen research capacity in underrepresented regions facing significant CDV disease burdens (Gebreyes et al., 2014). The concentration of studies at the University of Bern, the University of California system and the University of Veterinary Medicine Hannover highlights the importance of sustained institutional commitment to productive research programs. An analysis of the authors identified Zurbriggen A. and Vandeveld M. as the most influential researchers on this topic, with both achieving high productivity and high citation impact (each with an h-index of 33). Their pioneering work on CDV neuropathology and demyelination mechanisms has fundamentally shaped the current understanding of disease pathogenesis (Vandeveld and Zurbriggen, 2005; Zurbriggen et al., 1995). Collaboration networks represent moderately interconnected research communities with distinct geographical clusters. While international partnerships exist on this topic, more intensive intercontinental collaborations may provide opportunities to strengthen global connectivity through targeted exchange programs and collaborative funding mechanisms (Katz and Martin, 1997).

This analysis reveals several research opportunities. The limited interest in therapeutic interventions and new vaccine platforms highlights the need for translational research. Despite CDV's relevance to wildlife conservation and infections in uncommon hosts, the modest representation of One Health perspectives suggests a need for more integrated approaches (Zinsstag et al., 2011). The concentration of research in specific geographic areas underscores the necessity of capacity building in underrepresented regions.

CONCLUSION

This bibliometric analysis of 2,842 publications from 1980 to 2024 provides a comprehensive overview of global research into canine distemper. The topic has experienced significant growth, particularly between 2005 and 2015, due to advances in molecular technology and increased awareness of wildlife conservation. Geographic analysis revealed a concentration in high-income countries (the US accounting for 38%, China for 11%, and Germany for 10%), as well as enhanced global partnerships and capacity-building opportunities in underrepresented regions. The leading institutions involved (the University of Bern, the University of California system and the Hannover University of Veterinary Medicine) highlight the importance of sustained institutional support for this field of research. Zurbriggen A. and Vandeveld M. emerged as the most influential researchers, whose contributions to CDV neuropathology continue to shape current research (h-index = 33 each).

Key research gaps include a lack of interest in therapeutic interventions and vaccine development, poor integration of the One Health approach and uneven geographical research coverage. Future research should emphasise translational applications, strengthen global research partnerships, integrate One Health approaches and pay equal attention to fundamental biological questions and applied control strategies. The sustained publication output demonstrates that canine distemper is an area of ongoing relevance to veterinary medicine, wildlife conservation and comparative virology.

This study is intended to serve as a guide for researchers interested in the canine distemper virus. However, there are some limitations that should be considered. These include the limited availability of the reviewed studies within the Web of Science database, and the fact that only English-language publications were included, which may underrepresent research published in other languages and introduce a language bias into the findings (Amano et al., 2016). Despite these limitations, the analysis provides a comprehensive quantitative evaluation of research in the field of

canine distemper.

Acknowledgements

Not applicable.

Ethics Approval

This study did not involve animal subjects or human participants. All data were obtained from publicly available scientific databases.

Funding

There is not any funding in this study.

Conflict of Interest

The authors declare that they have no conflict interests regarding the publication of this article.

Author Contributions

Research Design (CRediT 1) Author 1 (%60) – Author 2 (%40)

Data Collection (CRediT 2) Author 1 (%100)

Research - Data analysis - Validation (CRediT 3-4-6-11) Author 1 (%40) – Author 2 (%60)

Writing the Article (CRediT 12-13) Author 1 (%100)

Revision and Improvement of the Text (CRediT 14) Author 1 (%40) – Author 2 (%60)

Sustainable Development Goals (SDG)

Sustainable Development Goals: 3 Good Health and Well-Being

REFERENCES

- Amano, T., González-Varo, J.P., Sutherland, W.J. (2016). Languages are still a major barrier to global science. *PLoS Biology*, 14(12): e2000933.
- Appel, M.J., & Summers, B.A. (1995). Pathogenicity of morbilliviruses for terrestrial carnivores. *Veterinary Microbiology*, 44(2-4): 187-191.
- Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, 11(4): 959-975.
- Beineke, A., Baumgärtner, W., Wohlsein, P. (2015). Cross-species transmission of canine distemper virus-an update. *One Health*, 1: 49-59.
- Christopher, M.M., & Marusic, A. (2013). Geographic trends in research output and citations in veterinary medicine: Insight into global research capacity, species specialization, and interdisciplinary relationships. *BMC Veterinary Research*, 9: 115.
- Deem, S.L., Spelman, L.H., Yates, R.A., et al. (2000). Canine distemper in terrestrial carnivores: a review. *Journal of Zoo and Wildlife Medicine*, 31(4): 441-451.
- Donthu, N., Kumar, S., Mukherjee, D., et al. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133: 285-296.
- Elasan, A., & Sahin, A. (2025). Comprehensive global analysis of future trends in artificial intelligence-assisted veterinary medicine. *Veterinary Medicine and Science*, 11(2): e70258.
- Gebreyes, W.A., Dupouy-Camet, J., Newport, M.J., et al. (2014). The global one health paradigm: challenges and opportunities for tackling infectious diseases at the human, animal, and environment interface in low-resource settings. *PLoS Neglected Tropical Diseases*, 8(11): e3257.
- Hirsch, J.E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences USA*, 102(46): 16569-16572.
- Katz, J.S., & Martin, B.R. (1997). What is research collaboration? *Research Policy*, 26(1): 1-18.
- Lawson, J.L., Gallo, V., Colquhoun, D., et al. (2025). How COVID-19 affected academic publishing: a 3-year study of 17 million research papers. *International Journal of Epidemiology*, 54(3): dyaf058.
- Mahdy, M.A.A. (2020). The impact of COVID-19 pandemic on the academic performance of veterinary medical students. *Frontiers in Veterinary Science*, 7: 594261.
- Martella, V., Elia, G., Buonavoglia, C. (2008). Canine distemper virus. *Veterinary Clinics of North America Small Animal Practice*, 38(4): 787-797.
- Moral-Muñoz, J.A., Herrera-Viedma, E., Santisteban-Espejo, A., et al. (2020). Software tools for conducting bibliometric analysis in science: An up-to-date review. *Profesional de la Información*, 29(1): e290103.
- Panzer, Y., Sarute, N., Iraola, G., et al. (2015). Molecular phylogeography of canine distemper virus: Geographic origin and global spreading. *Molecular Phylogenetics and Evolution*, 92: 147-154.
- Petersen, O.H. (2021). Inequality of research funding between different countries and regions is a serious problem for global science. *Function*, 2(6): zqab060.

- Pranckutė, R. (2021). Web of Science (WoS) and Scopus: The titans of bibliographic information in today's academic world. *Publications*, 9(1): 12.
- Qiu, W., Zheng, Y., Zhang, S., et al. (2011). Canine distemper outbreak in rhesus monkeys, *China*. *Emerging Infectious Diseases*, 17(8): 1541-1543.
- Riley, M.C., & Wilkes, R.P. (2015). Sequencing of emerging canine distemper virus strain reveals new distinct genetic lineage in the United States associated with disease in wildlife and domestic canine populations. *Virology Journal*, 12: 219.
- Seimon, T.A., Miquelle, D.G., Chang, T.Y., et al. (2013). Canine distemper virus: an emerging disease in wild endangered Amur tigers (*Panthera tigris altaica*). *mBio*, 4(4): e00410-13.
- Shin, Y.J., Cho, K.O., Cho, H.S., et al. (2004). Comparison of one-step RT-PCR and a nested PCR for the detection of canine distemper virus in clinical samples. *Australian Veterinary Journal*, 82(1-2): 83-86.
- Tennant, J.P. (2020). Web of Science and Scopus are not global databases of knowledge. *European Science Editing*, 46: e51987.
- Uzabaci, E., Ozen, D., Ural, K. (2025). Evaluation of the 100 most-cited articles published in veterinary journals. *Veterinary Medicine and Science*, 11(4): e70545.
- Vandeveld, M., & Zurbriggen, A. (2005). Demyelination in canine distemper virus infection: a review. *Acta Neuropathologica*, 109(1): 56-68.
- Wickham, H. (2016). ggplot2: Elegant graphics for data analysis. New York, USA: Springer-Verlag.
- Zinsstag, J., Schelling, E., Waltner-Toews, D., et al. (2011). From "one medicine" to "one health" and systemic approaches to health and well-being. *Preventive Veterinary Medicine*, 101(3-4): 148-156.
- Zurbriggen, A., Graber, H.U., Wagner, A., et al. (1995). Canine distemper virus persistence in the nervous system is associated with noncytolytic selective virus spread. *Journal of Virology*, 69(3): 1678-1686.

Prevalence and Significance of Gastrointestinal Parasites in Turkeys (*Meleagris gallopavo*) in Konya

Burak ÇELİK¹, Ayşe EVCI², Bengi Su ŞAHİN¹, Ahmet Can KAYA¹,
Nermin IŞIK USLU²

¹ Selçuk University Institute of Health Sciences, Konya, Türkiye

² Selçuk University Faculty of Veterinary Medicine, Department of Parasitology, Konya, Türkiye

Article Info	ABSTRACT
Received: 27.04.2026 Accepted: 18.06.2026 Online first: 21.07.2026 Published: 27.07.2026 Keywords: <i>Cryptosporidium</i> spp., <i>Giardia</i> spp., Protozoan, Zoonosis.	Gastrointestinal parasite in turkeys are important because they cause clinical infections and pose a zoonotic risk. This study aimed to determine the prevalence of gastrointestinal parasites in turkeys raised in Konya and to evaluate the obtained data from an epidemiological perspective. The study material consisted of the feces of 86 turkeys, aged 2 months (n=76) and 6 months (n=10), from an intensive farm. Descriptive information for the sampled turkeys was recorded for each animal. Freshly collected stool samples were brought to the Parasitology Department Laboratory of Selçuk University Faculty of Veterinary Medicine. Stool samples brought to the laboratory were first examined macroscopically to check for cestode segments or other adult helminths. Subsequently, in order to perform parasitic examination under appropriate conditions, all stool samples were examined for gastrointestinal parasites using the Native examination, Fulleborn Flotation with saturated NaCl solution, and Modified Ziehl-Neelsen methods. In 56.97% (49/86) of the stool samples, cysts and oocysts of gastrointestinal protozoa were observed. <i>Giardia</i> spp. cysts were found in 54.65% (47/86) of turkeys, and <i>Cryptosporidium</i> spp. oocysts were found in 4.65% (4/86). No helminth eggs were observed. Of the turkeys whose feces were examined at least one parasitic agent was found in 49, while no parasitic agents were found in 37. Fisher's exact test revealed that the difference was not statistically significant (p=1.000). When evaluating alternative production models for meeting Türkiye's animal protein requirements, turkeys hold a significant place. Considering the gastrointestinal parasites in turkeys, which can cause yield loss and mortality, it is recommended that research on these factors continue.

To cite this article:

Celik B., Evcı A., Şahin B.S., Kaya A.C., Işık Uslu N. (2026). Prevalence and Significance of Gastrointestinal Parasites in Turkeys (*Meleagris gallopavo*) in Konya. *Research and Practice in Veterinary and Animal Science (REPVAS)*, 3(2), 79-87.

<https://doi.org/10.69990/REPVAS.2026.3.2.2>

***Corresponding Author:** Burak Çelik, burakcelik12032001@gmail.com

INTRODUCTION

With population growth in Türkiye and globally, nutrition problems are becoming increasingly significant (Godfray et al., 2010). Nutritional deficiencies weaken the immune system, thereby increasing susceptibility to infections (Katona and Katona-Apte, 2008). Regular consumption of animal-derived foods and adequate protein intake from these sources is important for human health, particularly in children and young people, as it supports growth, cognitive function, and mental development (Ünsal, 2019).

Alternative production models for meeting Türkiye's animal protein requirements are being investigated, and poultry farming is widespread due to its compatibility with industrial production systems. While chickens are the primary species in poultry production, turkeys represent an economically valuable alternative with lower fat and cholesterol content and high protein value (Marangoni et al., 2015; Arslan and Çetin, 2022). According to the Turkish Statistical Institute's 2025 data, there are 3,192,168 turkeys nationwide, and in Konya province, where the study was conducted, this number is 27,223. The majority of these turkeys are bronze turkeys (Arslan, 2022; TÜİK, 2025).

There are numerous pathogenic and non-pathogenic factors that can lead to yield losses and mortality in turkeys (Arslan and Çetin, 2022). Among these, parasitic agents are among the main causes of production losses and mortality. Various helminth and protozoan species, particularly those residing in the gastrointestinal system, can cause clinical symptoms such as diarrhea, loss of productivity, and general malaise (McDougald, 2020). The helminths that infest the gastrointestinal system of turkeys vary widely. Nematode species such as *Ascaridia galli* and *Capillaria caudinflata* cause diarrhea and general discomfort, while less pathogenic nematodes such as *Heterakis gallinarum* are also found. However, these helminths act as vectors for more pathogenic protozoan agents such as *Histomonas meleagridis*. Along with these commonly seen helminths, less common cestode species such as *Railletina cesticillus* and *Davainea proglottina* are also observed (Doğanay, 2018; Öge, 2018; McDougald, 2020).

Protozoan parasites such as *Giardia* spp., *Cryptosporidium* spp., and *Eimeria* spp. can be detected in the gastrointestinal systems of turkeys. These parasites can cause clinical signs such as diarrhea, loss of productivity, and general malaise (Goodwin et al., 1988; Karaer and Kar, 2010). It has also been reported that *Cryptosporidium* spp. can settle in the respiratory system in addition to the intestine (Tarwid et al., 1985).

Given the transmission risks of these parasites, periodic fecal monitoring at production facilities is essential for updating epidemiological data and establishing robust strategies for the control and prevention of parasitic infections (Muriu, 2023).

MATERIAL and METHODS

Stool Samples

The material for this study consists of fecal samples from a total of 86 bronze turkeys (76 2 months old and 10 6 months old) received from an intensive farm at the Parasitology Department Laboratory of Selçuk University Faculty of Veterinary Medicine between October 2025 and December 2025.

Parasitological Examination of Stool Samples

Stool samples were primarily evaluated macroscopically for cestode proglottids and adult gastrointestinal helminths. All samples were then examined by native fecal examination; subsequently,

the Fulleborn flotation method with saturated NaCl solution was applied to investigate helminth eggs, protozoan cysts, and oocysts. In this flotation procedure, the density of the solution was standardized (specific gravity: 1.18–1.20), and diagnostic criteria included egg morphology, size, and shell characteristics. For each sample, a minimum of 10 microscopic fields were systematically examined under $\times 10$ and $\times 40$ magnification to ensure diagnostic accuracy. Quality control procedures were implemented by re-examining 10% of randomly selected samples by a second parasitologist to confirm reproducibility of findings.

In addition, thin fecal smear preparations were made and microscopic examination was performed for *Cryptosporidium* spp. oocysts using the Modified Ziehl-Neelsen (MZN) technique. All parasitological diagnostic methods were performed following the standard protocols defined by Güçlü (2006) and Kaya (2010).

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics v27.0 (IBM Corp., Armonk, NY, USA) software package. The relationship between age groups (2 months vs. 6 months) and the presence of infection was evaluated using Fisher's exact test. A p -value < 0.05 was considered statistically significant. Prevalence values are presented as n (%) with 95% exact (Clopper-Pearson) confidence intervals (CI), as detailed in Table 2.

RESULTS

In 56.97% ($n=49$) of the 86 stool samples examined in the study, cysts and oocysts of protozoa located in the gastrointestinal system were observed. Table 1 shows the distribution of infections in animals identified as infected with parasitic agents.

Table 1. Infection distribution in animals infected with parasitic agents. Distribution of parasitic agents in examined turkeys.

	n (%)
Mono Infection	
<i>Giardia</i> spp.	45 (52.32%)
<i>Cryptosporidium</i> spp.	2 (2.32%)
Mix Infection	
<i>Giardia</i> spp. + <i>Cryptosporidium</i> spp.	2 (2.32%)

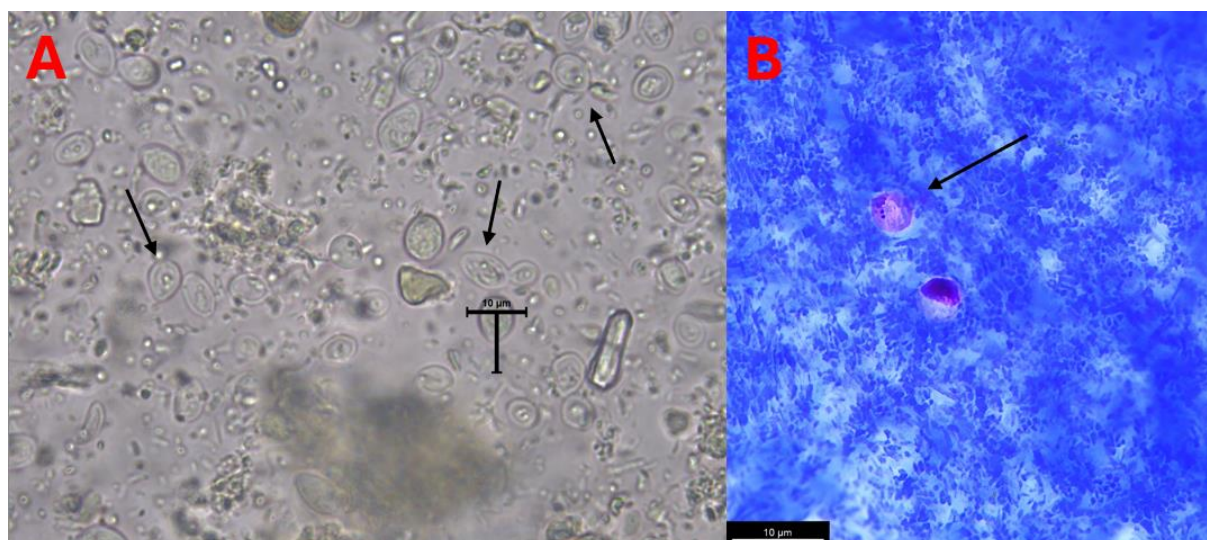
In turkeys whose fecal samples were examined for parasites, *Giardia* spp. cysts were found in 54.65% and *Cryptosporidium* spp. oocysts were found in 4.65%. No helminth eggs were observed. Of the turkeys whose feces were examined, at least one parasitic agent was found in 49, while no parasitic agents were found in 37.

This study evaluated the relationship between the presence of parasitic infections and age groups (2 months and 6 months) in the turkeys examined. The analysis revealed that parasitic agents were detected in 56.57% ($n=43/76$) of 2 month old turkeys and 60% ($n=6/10$) of 6 month old turkeys. Fisher's exact test revealed no statistically significant difference between age groups regarding the presence of infection ($p=1.000$). Similarly, the distribution of *Giardia* spp. ($p=1.000$) and *Cryptosporidium* spp. ($p=1.000$) did not differ significantly between age groups. Table 2 presents the distribution and statistical data of gastrointestinal parasite prevalence in turkeys according to age groups.

Table 2. Prevalence of gastrointestinal parasites and comparasion between age groups in turkeys and statistical data.

	Positive n (%)	Negative n (%)	<i>Giardia</i> spp. n (%)	<i>Cryptosporidium</i> spp. n (%)	Total number of animals n
Age					
2 month	43 (56.57%) (95% CI: 44.71%-67.92%)	33 (43.42%)	41 (53.94%) (95% CI: 42.13%-65.45%)	4 (5.26%) (95% CI: 1.45%-12.93%)	76
6 month	6 (60.00%) (95% CI: 26.24%-87.84%)	4 (40.00%)	6 (60.00%) (95% CI: 26.24%-87.84%)	0 (0.00%) (95% CI: 0.00%-30.85%)	10
Total	49 (56.97%) (95% CI: 45.85%-67.61%)	37 (43.02%)	47 (54.65%) (95% CI: 43.55%-65.42%)	4 (4.65%) (95% CI: 1.28%-11.48%)	86
p value	p=1.000		p=1.000	p=1.000	

Abbreviations: CI = Confidence Interval. Prevalence values are presented as n (%) with 95% exact (Clopper-Pearson) confidence intervals. Statistical comparisons between age groups were performed using Fisher's exact test. p values ≥ 0.05 indicate no statistically significant difference in parasite prevalence between the 2-month and 6-month age groups.

Figure 1. A: *Giardia* spp. cysts 100x, B: *Cryptosporidium* spp. oocysts 100x in the preparation stained with MZN staining

DISCUSSION

A study conducted in Konya on turkeys regarding gastrointestinal parasites, based on fecal examination, reported a prevalence of 24.66%. In this study, the parasitemia rate was found to be 56.97% (Sevinç et al., 2000). This data is significantly higher than the rates reported in the literature. This difference is thought to stem from variations in sampling strategies, diagnostic methods, and the time period in which the study was conducted.

Numerous helminth species have been reported in previous studies conducted on birds (Güçlü, 1992; Yardibi, 2004; Gürler et al., 2012). However, no helminth infection was found in this study. This situation is thought to be related to the fact that the samples were obtained from an intensive operation. Helminths, particularly trematodes and cestodes, require contact with an intermediate host

to complete their life cycles. In intensive farming systems, turkeys have limited contact with intermediate hosts and soil, which prevents helminth infections caused by environmental contamination. Conversely, the high prevalence rate observed in the study can be explained by the non-intermediate host life cycles and direct transmission of the protozoan agents encountered, as well as the inadequate hygiene practices in the establishments (Caccio et al., 2005; Toparlak and Tüzer, 2012).

Cryptosporidium spp., a major cause of diarrhea worldwide, is a zoonotic agent affecting both humans and farm animals. This disease is a life-threatening parasitic agent that causes severe diarrhea, particularly in infants and young animals whose immune systems are not yet fully developed, as well as in the elderly or individuals with weakened resistance due to illness, stress, or other reasons (Thompson et al., 2005; Fletcher et al., 2012; Checkley et al., 2015). To date, studies conducted in Türkiye have not detected *Cryptosporidium* spp. oocysts in turkeys; however, the presence of *Cryptosporidium* spp. is known in studies conducted worldwide (Slavin, 1955; Hoerr et al., 1978; Tarwid et al., 1985). These findings from the study represent one of the first epidemiological data regarding the presence of *Cryptosporidium* spp. in turkeys in Türkiye. In the study, *Cryptosporidium* spp., oocysts were detected in 5.26% (4/76) of 2 month old turkeys, while no infection (0/10) was observed in the 6 month old group. Despite the absence of infection in the older group, Fisher's exact test confirmed that this difference was not statistically significant ($p = 1.000$). This is thought to be related to the age related immune response to infection. In older animals, immunity to *Cryptosporidium* spp. leads to decreased oocyst shedding, which can result in the pathogen not being detectable microscopically in stool preparations (Checkley et al., 2015).

Due to its wide host range and high environmental resistance, *Giardia* spp., a zoonotic parasite, increases the risk of infection and prevalence in farm environments. This pathogen, which can be transmitted through contaminated water, feed, and bedding, can lead to clinical signs such as diarrhea, loss of productivity, and general malaise in infected individuals (Karaer and Kar, 2010). Given the multispecies housing conditions at the study site, these animals are thought to play a carrier role in the dissemination of *Giardia* spp., a parasite characterized by low host specificity (Karaer and Kar, 2010; Adam, 2021). Although the presence of *Giardia* spp. in turkeys has not been reported in Türkiye in previous years, studies conducted in different parts of the world have reported the presence of this pathogen (Reboredo-Fernandez et al., 2015; Talazadeh et al., 2024). Parasitic agents were detected in 56.57% (43/76) of 2 month old turkeys and 60% (6/10) of 6 month old turkeys. Statistical analysis using Fisher's exact test showed no significant relationship between age groups and the general presence of infection ($p = 1.000$). This finding is consistent with results reported in the literature, showing that age is not a determining factor in the spread of *Giardia* spp. (Alegre et al., 2021; Ussenbayev et al., 2025).

There are no historical reports of *Giardia* spp. presence in turkeys in Türkiye. However, studies conducted in different parts of the world have reported the presence of this pathogen in turkeys (Reboredo-Fernandez et al., 2015; Talazadeh et al., 2024). These findings represent one of the first epidemiological data regarding the presence of *Giardia* spp. in turkeys in Türkiye.

In this study, parasitic findings obtained from turkeys in Konya are based solely on microscopic examination. However, factors such as irregular excretion of parasites in feces, morphological similarities, and low cyst and oocyst density can limit the sensitivity of microscopic examination. Studies in the literature on different animal species show that molecular and serological methods are superior in identifying low-level infections that cannot be detected by microscopy. Therefore, supporting these findings with advanced diagnostic methods is crucial for fully determining the parasitic load and zoonotic risks in the region (Checkley et al., 2015; Çelik et al., 2023).

CONCLUSION

In a general assessment, the fundamental problems of turkey farming enterprises in Konya include insufficient technical support, infrastructure deficiencies, and a lack of adequate education and knowledge among the personnel (Arslan et al., 2020). The findings indicate that the potential risk of parasitic infections in turkeys cannot be ignored. Therefore, enhancing biosecurity measures in turkey farming, ensuring litter and feed hygiene, preventing the movement of free-ranging animals, and conducting regular parasitological screenings are of critical importance for both animal health and the mitigation of zoonotic risks (Permin and Hansen, 1998; Ryan and Hijjawi, 2015).

Ethics Approval

27/03/2026 dated 2026/48 and numbered was given by Selçuk University, SÜVDAMEK ethics committee.

Funding

No person/organization financially supported the study.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

Research Design (CRediT 1) Author 5 (%60) – Author 1 (%40)

Data Collection (CRediT 2) Author 1 (%40) – Author 3 (%30)- Author 4 (%30)

Research - Data analysis - Validation (CRediT 3-4-6-11) Author 1 (%100)

Writing the Article (CRediT 12-13) Author 1 (%60) – Author 2 (%40)

Revision and Improvement of the Text (CRediT 14) Author 5 (%70) – Author 2 (%30)

Sustainable Development Goals (SDG)

Goal 2: Zero Hunger

Goal 3: Good Health and Well-Being

Goal 15: Life on Land

REFERENCES

- Adam, R.D. (2021). Biology of *Giardia lamblia*. *Clinical Microbiology Reviews*, 34(1): e00024-19.
- Alegre, R.E., Gennuso, M.S., Milano, F. & Kowalewski, M. (2021). Relationship between age-sex classes and prevalence of *Giardia* spp. and *Blastocystis* spp. in black and gold howler monkeys inhabiting fragmented forests. *Therya*, 12(3): 563-569.
- Arslan, E. (2022). Farklı yetiştirme sistemlerinde Amerikan Bronz Hindilerin büyüme, besi performansı, kesim ve karkas özellikleri. PhD Thesis, Selcuk University, Konya, Türkiye.
- Arslan, E. & Çetin, O. (2022). Hindi yetiştiriciliği. İçinde: Akmaç A, İnal Ş, Garip M (editörler). Zootekni III. Konya, Türkiye: Selçuk Üniversitesi Basımevi. ss. 49-83.
- Arslan, E., Çetin, O. & Günlü, A. (2020). Konya bölgesindeki hindi yetiştiriciliğinin mevcut durumu ve bazı sorunlarının değerlendirilmesi. *MAE Veteriner Fakültesi Dergisi*, 5(3): 111-123.
- Baéza, E., Guillier, L. & Petracci, M. (2021). Review: Production factors affecting poultry carcass and meat quality attributes. *Animal*, 15(12): 100331.
- Caccio, S.M., Thompson, A.R.C., McLauchlin, J. & Smith, H.V. (2005). Unravelling *Cryptosporidium* and *Giardia* Epidemiology. *Trends Parasitol*, 21(9): 430-437.
- Checkley, W., White, A.C., Jaganath, D., et al. (2015). A review of the global burden, novel diagnostics, therapeutics, and vaccine targets for *Cryptosporidium*. *The Lancet Infectious Diseases*, 15(1): 85-94.
- Çelik, Ö.Y., Çelik, B.A., Ayan, A., et al. (2023). Siirt'te kuzularda *Giardia duodenalis*'in mikroskopik ve moleküler araştırması. *Dicle Üniversitesi Veteriner Fakültesi Dergisi*, 16(2): 71-74.
- Dezfoulan, O., Gharagozlu, M.J., Rahbari, S. & Samani, R.A. (2010). Coccidiosis due to various species of *Eimeria* in the stunted and diarrheic native turkey poult: pathology and morphological characterization of oocysts. *Archives of Razi Institute*, 65(1): 15-19.
- Doğanay, A. (2018). *Cestoidea Cyclophyllidea*. İçinde: Doğanay A (editör). Helmintholoji. Ankara, Türkiye: Ankara Nobel Tıp Kitapevleri. ss. 90-95.
- Fletcher, S.M., Stark, D., Harkness, J. & Ellis, J. (2012). Enteric protozoa in the developed world: a public health perspective. *Clinical Microbiology Reviews*, 25(3): 420-449.
- Godfray, H.C.J., Beddington, J.R., Crute, I.R., et al. (2010). Food security: the challenge of feeding 9 billion people. *Science*, 327(5967): 812-818.
- Goodwin, M.A., Steffens, W., Russell, I.D. & Brown, J. (1988). Diarrhea associated with intestinal *Cryptosporidiosis* in turkeys. *Avian Diseases*, 32(1): 63-67.
- Güçlü, F. (1992). Ankara civarında tavuk, hindi, ördek ve kazlarda helminth faunası. PhD Thesis, Ankara University, Ankara, Türkiye.
- Güçlü, F. (2006). Parazitolojik Teşhis Metotları. Konya, Türkiye: Ümit Baskı. ss. 12-24.
- Gürler, A., Bölükbaş, C., Pekmezci, G., Umur, Ş. & Acici, M. (2012). Samsun'da sülünlerde (*Phasianus colchicus*) nekropsi ve dışkı bakısında saptanan helminthler. *Türkiye Parazitoloji Dergisi*, 36(4): 230-235.
- Hoerr, F.J., Ranck, F.M. & Hastings, T.F. (1978). Respiratory cryptosporidiosis in turkeys. *Journal of the American Veterinary Medical Association*, 173(12): 1591-1593.

- Karaer, Z. & Kar, S. (2010). *Hexamitidae*. İçinde: Dumanlı N, Karaer Z (editörler). Veteriner Protozooloji. Ankara, Türkiye: Medisan Yayınevi. ss. 43-47.
- Katona, P. & Katona-Apte, J. (2008). The interaction between nutrition and infection. *Clinical Infectious Diseases*, 46(10): 1582-1588.
- Kaya, G. (2010). Protozoolojide tanı yöntemleri. İçinde: Dumanlı N, Karaer Z (editörler). Veteriner Protozooloji. Malatya, Türkiye: Medipres. ss. 239-251.
- Keskin, B. & Demirbaş, N. (2012). Türkiye’de Kanatlı Eti Sektöründe Ortaya Çıkan Gelişmeler: Sorunlar ve Öneriler. *Uludağ Üniversitesi Ziraat Fakültesi Dergisi*, 26(1): 117-130.
- Mafruchati, M. (2020). Broiler Chicken vs. Turkey Meat; which One Has the Least Bad Fat to Avoid Positive Case of COVID-19?. *Systematic Reviews in Pharmacy*, 11(10): 755-759.
- Marangoni, F., Poli, A., Agostoni, C. et al. (2015). Role of poultry meat in a balanced diet aimed at maintaining health and wellbeing: an Italian consensus document. *Food & Nutrition Research*, 59(1): 27606.
- McDougald, L.R. (2020). Internal parasites. In: Swayne D.E., et al. (Ed.). *Diseases of Poultry*. 14th ed. Wiley-Blackwell. ss. 1157–1191.
- Muriu, J. (2023). Impact of parasites and parasitic diseases on animal health and productivity. *Journal Animal Health*, 3(1): 13-23.
- Öge, S. (2018). *Ascaridida* Ascaridoidea. İçinde: Doğanay A (Ed.). *Helmintoloji*. Ankara, Türkiye: Ankara Nobel Tıp Kitapevleri. pp. 269-274.
- Permin, A. & Hansen, J.W. (1998). Epidemiology, diagnosis and control of poultry parasites. Roma, İtalya: FAO Animal Health Paper. pp. 160.
- Reboredo-Fernandez, A., Ares-Mazas, E., Caccio, S.M. & Gomez-Couso, H. (2015). Occurrence of *Giardia* and *Cryptosporidium* in wild birds in Galicia (Northwest Spain). *Parasitology*, 142(7): 917-925.
- Ryan, U., & Hijawi, N. (2015). New developments in *Cryptosporidium* research. *International Journal for Parasitology*, 45(6): 367-373.
- Sevinç, F., Güçlü, F., Yaman, M. & Altınöz, F. (2000). The Prevalence of gastrointestinal parasites of turkeys (*Meleagris gallopavo*). *Eurasian Journal of Veterinary Sciences*, 16(2): 15-19.
- Slavin, D. (1955). *Cryptosporidium meleagridis* (spp. nov.). *Journal of Comparative Pathology and Therapeutics*, 65: 262-266.
- Talazadeh, F., Razijalali, M.H., Masae Manesh, M. & Khajeh, F. (2024). Investigation of enteric parasites with a focus on zoonotic parasites in the feces of galliformes. *Archives of Razi Institute*, 79(2): 379.
- Tarwid, J.N., Cawthorn, R.J. & Riddell, C. (1985). Cryptosporidiosis in the respiratory tract of turkeys in Saskatchewan. *Avian Diseases*, 29(2): 528-532.
- Thompson, R.A., Olson, M.E., Zhu, G., et al. (2005). *Cryptosporidium* and cryptosporidiosis. *Advances in Parasitology*, 59: 77-158.
- Toparlak, M. & Tüzer, E. (2012). Veteriner Helmintoloji (Cilt 3). İstanbul, Türkiye: Prof. Dr. Müfit Toparlak.

- TÜİK. (2025). Hayvancılık İstatistikleri. <https://biruni.tuik.gov.tr/medas/?kn=92&locale=tr>, Erişim tarihi: 04.06.2026.
- Ussenbayev, A., Kurenkeyeva, D., Aydin, A., et al. (2025). Prevalence and infestation dynamics of intestinal protozoa infections among calves in dairy farms of Kazakhstan. *Frontiers in Veterinary Science*, 12: 1635456.
- Ünsal, A. (2019). Beslenmenin önemi ve temel besin öğeleri. *Kırşehir Ahi Evran Üniversitesi Sağlık Bilimleri Dergisi*, 2(3): 1-10.
- Yardibi, M.E. (2004). Hindilerde sindirim sistemi helmintlerinin araştırılması. PhD Thesis, Ankara University, Ankara, Türkiye.

Nutrient Digestibility of Red Sokoto Goats During the Dry Hot Season of Derived Savanna Zone of Nigeria

Adedeji Ayobami ISIAH* 

Ladoke Akintola University of Technology, Faculty of Agricultural Science, Department of Animal Nutrition and Biotechnology, Ogbomoso Oyo State, Nigeria

Article Info	ABSTRACT
Received: 11.05.2026 Accepted: 30.06.2026 Online first: 21.07.2023 Published: 27.07.2026 Keywords: ADF, Derived savanna, Dry hot season, NDF, Red Sokoto Goats.	Water availability is a major environmental factor that influences the feed intake, nutrient utilization and productivity of ruminants, particularly during the dry season in tropical regions. This study examined the impact of different water restriction regimes on the nutrient digestibility of Red Sokoto goats fed groundnut straw in the hot, dry season in Savannah zone of Nigeria's. Six mature Red Sokoto bucks, aged between one and one-and-a-half years and weighing between 12 and 14 kg, were used in a multi-period crossover experiment involving ad libitum water supply (control), 30% water restriction and 50% water restriction treatments. Feed and water intake and fecal output were measured daily, while proximate composition and fiber fractions were analyzed using AOAC procedures. The results showed that water restriction significantly reduced the digestibility coefficients of dry matter, crude protein (CP), crude fiber (CF), neutral detergent fiber (NDF) and acid detergent fiber (ADF) ($P<0.05$). Dry matter digestibility decreased from 77.64% in the control group to 72.00% in the group subjected to a 50% water restriction, while crude protein digestibility declined from 50.43% to 29.18%. These findings are consistent with previous reports indicating that inadequate water intake negatively impacts nutrient utilization and rumen function in ruminants. The study concluded that restricting water adversely affects the digestibility of nutrients in Red Sokoto goats, which may consequently reduce their productivity during periods of water scarcity. Therefore, adequate access to clean drinking water should be prioritized in goat production systems, particularly in semi-arid environments during the dry hot season.

To cite this article:

Isaiah, A.A. (2026). Nutrient Digestibility of Red Sokoto Goats During the Dry Hot Season of the Derived Savanna Zone of Nigeria, *Research and Practice in Veterinary and Animal Science (REPVAS)*, 3(2), 88-94. <https://doi.org/10.69990/REPVAS.2026.3.2.3>

***Corresponding Author:** Adedeji Ayobami Isaiah, haryoobam1993@gmail.com

INTRODUCTION

Water is one of the most essential nutrients required by livestock for survival, growth, digestion, metabolism, thermoregulation and excreting waste (Choshniak et al., 1994; Beede, 2009). In ruminants, water constitutes 50–80% of body weight, depending on age and physiological status (Lardner et al., 2005). Adequate water intake is necessary to maintainance, including nutrient transport, enzymatic reactions, rumen fermentation and the maintenance of osmotic balance (Murphy, 1992). In contrast to feed deprivation, animals subjected to severe water restriction can rapidly develop dehydration, reduced productivity and metabolic disturbances that may threaten survival (Faires et al., 2007).

In tropical and semi-arid regions such as Nigeria, seasonal water scarcity poses a significant challenge to the sustainable production of livestock. During the dry season, the combination of high ambient temperatures and poor water availability often exposes ruminants to heat stress and dehydration (Alamer, 2006). Restricting water intake has been associated with reduced feed consumption, decline of weight gain, impaired nutrient absorption and poorer productivity in goats and sheep (Casamassima et al., 2008; Abdelatif et al., 2010). Toha et al. (1987) found that water intake is quantitatively related to feed intake and nutrient utilization in ruminants. A reduction in water intake often results in lower dry matter intake and altered rumen fermentation dynamics.

Goats play a particularly important role in Nigeria's livestock sector due to their ability to thrive in challenging environments and their contribution to the production of meat, milk, hides and skins, as well as their value in generating household income (Devendra and McLeroy, 1982). The Red Sokoto goat, which is widely distributed in Nigeria, is one of the most important indigenous goats breeds due to its adaptability and economic value. However, there is limited information regarding the effects of water restriction on nutrient digestibility in indigenous goat breeds under local production systems.

Groundnut straw is commonly used as supplementary feed resources for ruminants during the dry season because of their availability (Ayantunde et al., 2008). However, the effectiveness of such feed resources may be influenced by water availability, especially under hot environmental conditions.

Therefore, this study was conducted to evaluate the effects of different water restriction regimes on nutrient digestibility of Red Sokoto goats fed groundnut straw during the dry hot season of the derived savanna zone of Nigeria.

MATERIAL and METHODS

The experiment was conducted at the Teaching and Research Farm of Ladoké Akintola University of Technology (LAUTECH), Ogbomoso, Oyo State, Nigeria. A total of six mature Red Sokoto bucks aged between one and one and half years with body weights ranging from 12 to 14 kg were used for the study. Prior to the initial of the experiment, all animals were quarantined for three weeks and treated against internal and external parasites to ensure optimal health status.

The sample size of six animals was chosen based on the logistical and intensive operational demands of total fecal collection protocols in individual metabolic cages. This cohort size aligns with standard sample sizes for intensive ruminant crossover metabolism studies, where individual variations are statistically minimized by assigning each animal to serve as its own control across successive periods.

The goats were housed individually in metabolic cages explicitly equipped with separate feeding and watering facilities to enable accurate, independent measurement of feed intake, water intake, and fecal output. To control for individual animal variation within a specialized metabolism

cohort, the experiment was executed using a multi-period crossover design layout spanning three (3) sequential experimental periods (Treatment Periods; TPs). The six bucks were balanced by body weight and assigned to treatment sequences that allowed each animal to receive all three water restriction regimes across successive experimental periods. This crossover arrangement enabled each goat to serve as its own control, thereby reducing the influence of individual animal variation on treatment comparisons. The three designated water treatment levels evaluated were:

- Ad libitum water supply (Control),
- 30% voluntary water restriction, and
- 50% voluntary water restriction.

Each experimental period lasted for 12 days, consisting of a 7-day adaptation phase followed by a 5-day total sample collection phase. During the adaptation period, animals adjusted to their respective water restriction levels before data collection commenced. At the end of each treatment period, animals were rotated to the next treatment sequence. Throughout the experiment, goats were fed groundnut straw *ad libitum* at 4% of their body weight on a dry matter basis to ensure feed offers exceeded daily intake. Feed was offered twice daily at 08:00 h and 16:00 h, and water was supplied according to the designated treatment levels. To isolate true animal water consumption from environmental losses, evaporation rate was monitored daily using blank control buckets placed adjacent to the pens and subtracted from water remnants (Alamer, 2006).

Ethics Statement

Decision of the ethics committee: The experimental protocols were conducted in accordance with the standard methods for the care and use of laboratory animals at the research institution.

Statistical Analysis

Data was analyzed using the MIXED procedure of SAS software (SAS Institute Inc., Cary, NC, USA). Water restriction treatment and experimental period were included as fixed effects, while individual animal was included as a random effect. Treatment means were separated using Duncan's Multiple Range Test, and differences were considered significant at $P < 0.05$. Duncan's test was selected to maximize statistical sensitivity for identifying specific pairs of treatment differences within this tightly controlled, small-cohort metabolic environment ($n=6$), minimizing Type II error inflation across the uniform experimental sequences.

Because the experiment employed a crossover design, a 7-day adaptation period was implemented before each collection phase to minimize potential carryover effects between treatment periods. However, sequence and carryover effects were not formally included in the final statistical model and therefore represent a limitation of the present study

RESULTS

Table 1. Chemical composition of groundnut straw fed to Red Sokoto goats subjected to three water restriction regimes.

Chemical composition	Values (%)
Dry matter	93.98
Crude protein	6.13
Crude fibre	30.01
Ether extract	02.01
Ash	06.02
Neutral detergent fibre (NDF)	52.01
Acid detergent fibre (ADF)	36.13

Table 1 shows the chemical composition of groundnut straw fed to Red Sokoto goats subjected to three water restriction regimes. The dry matter values obtained are 93.98%, crude protein value is 6.13%, crude fibre value is 30.01%, extract value is 2.01%, ash value is 6.02%, neutral detergent fibre value is 52.01%, acid detergent fibre value is 36.13% respectively.

Table 2. Nutrient digestibility of Red Sokoto goats as affected by three water restriction regimes

% Nutrient digestibility	Adlibitum	30% Water Restriction	50% Water Restriction	SEM	df	F-Value	P-Value
Dry Matter	77.64 ^a	76.19 ^b	72.00 ^c	0.13	2	45.21	<0.001
Crude Protein	50.43 ^a	37.65 ^b	29.18 ^c	0.50	2	114.86	<0.001
Crude Fiber	77.11 ^a	76.79 ^a	65.90 ^b	0.30	2	28.44	0.002
NDF	76.32 ^a	74.83 ^b	73.55 ^c	0.06	2	31.15	<0.001
ADF	74.50 ^a	70.21 ^b	68.09 ^c	0.15	2	48.92	<0.001

^{a,b,c} Means within a row with different superscripts differ significantly ($P < 0.05$). SEM = Standard Error of the Mean. df = Degrees of freedom associated with the treatment effect.

Table 2 presents the apparent digestibility coefficients for dry matter (DM), crude protein (CP), crude fibre (CF), neutral detergent fibre (NDF), and acid detergent fibre (ADF). Graded water restriction significantly reduced the digestibility of all evaluated nutrient parameters ($P < 0.05$). Dry matter digestibility decreased progressively as water restriction increased, ranging from 77.64% in the control group to 72.00% under 50% water restriction ($P < 0.001$). Crude protein digestibility exhibited a sharp decline across all treatments, dropping significantly from 50.43% (control) to 37.65% (30% restriction) and reaching a low of 29.18% under 50% water restriction ($P < 0.001$). For crude fibre, a significant reduction was observed under severe restriction (65.90%; $P = 0.002$), though the difference between the control (77.11%) and the 30% restriction treatment (76.79%) did not reach statistical significance. Structural fiber fractions also decreased significantly under restriction regimes, with NDF digestibility dropping from 76.32% to 73.55% ($P < 0.001$) and ADF digestibility declining from 74.50% to 68.09% ($P < 0.001$).

DISCUSSION

The results of this study showed that restricting the amount of water available to Red Sokoto goats significantly reduced nutrient digestibility. The observed reduction in dry matter digestibility as water restriction increased is consistent with previous findings by Bohra and Ghosh (1983), who reported that restricted water intake negatively affects dry matter utilization in ruminants. Reduced water availability may decrease rumen microbial activity and slow nutrient fermentation processes, thereby reducing the efficiency with which nutrients are utilised.

Crude protein digestibility also declined significantly as the level of water restriction increased. This finding confirms French's (1956) report of reduced crude protein utilization in cattle with restricted water intake. Water plays a key role in rumen nitrogen metabolism and microbial protein synthesis, so an inadequate water supply could hinder microbial growth and protein digestion (Toha et al., 1987). The low crude protein content (6.13%) of the groundnut straw used in this study may have further reduced the availability of nitrogen for rumen microorganisms.

A decrease in the digestibility of crude fibre, NDF and ADF under severe water restriction may be associated with reduced feed intake and altered rumen retention time. Balch et al. (1953) suggested that water deprivation affects the passage rate of digesta through the rumen, thereby influencing fiber degradation. Similarly, Riaz et al. (2014) reported that reduced feed intake under water stress conditions may impair fibre digestion due to slower microbial activity.

The findings of this study suggest that adequate water intake is crucial for efficient nutrient utilization in goats, especially during the dry season when environmental stress is high. As goats raised in semi-arid regions often have an intermittent water supply, prolonged water restriction could negatively impact their productivity, growth performance and overall health.

One limitation of this study was the relatively small sample size used in the experiment, which was mainly due to the intensive management and monitoring requirements associated with metabolic cage studies and total fecal collection procedures. Although the crossover experimental design helped reduce individual animal variation by allowing each goat to serve as its own control, the limited number of animals may still have reduced the statistical power and broader population inference of the findings. Nevertheless, despite the limited number of animals, the highly consistent response observed across all evaluated nutrient digestibility parameters strongly supports the biological relevance of the effects of water restriction on nutrient utilization in Red Sokoto goats. In addition, the experiment was conducted under controlled pen conditions, which may not fully represent field grazing systems under extensive tropical production environments. Therefore, further studies involving larger animal populations and longer experimental periods are recommended to validate these findings under wider production conditions.

Additionally, while the 7-day adaptation period was designed to deplete any residual physiological variations from preceding treatments, the exclusion of carryover and sequence effects from the statistical model remains a limitation. Future multi-period metabolic studies on tropical small ruminants should structurally integrate sequence parameters into the mixed models to fully rule out potential carryover biases

CONCLUSION

This study demonstrated that restricting the water supply had a significant impact on the nutrient digestibility of Red Sokoto goats fed groundnut straw during the hot, dry season. Increasing levels of water restriction reduced the digestibility of dry matter, crude protein, crude fibre, neutral detergent fibre and acid detergent fibre. These reductions suggest that inadequate water intake negatively impacts rumen function and nutrient utilization in goats.

The findings emphasize the importance of providing ruminants with adequate, clean drinking water, particularly during periods of high environmental temperature and limited water availability. Improving water management practices in goat production systems could enhance feed utilization efficiency, animal productivity and overall livestock performance in Nigeria's semi-arid regions.

Further studies involving larger populations of animals and additional physiological parameters are recommended to better understand the long-term effects of water restriction on indigenous goat breeds in tropical production systems.

Acknowledgements

The author thanks the Small Ruminant Unit (SRU) of the Ladoke Akintola University of Technology Teaching and Research Farm for providing the facilities to conduct this experiment.

Ethical Statement

This article has been produced from the research conducted during the author's undergraduate program.

Ethics Approval

The experimental protocols were conducted in accordance with the standard methods for the care and use of laboratory animals at the research institution.

Funding

There is not any funding in this study.

Conflict of Interest

The author declares no conflict of interest

Author Contributions

Research Design AdedejiAyobamiIsaiah (%100)

Data Collection Adedeji AyobamiIsaiah (%100)

Research - Data analysis Adedeji AyobamiIsaiah (%100)

Writing the Article Adedeji Ayobami Isaiah (%100)

Revision and Improvement of the Text Adedeji Ayobami Isaiah (%100)

Sustainable Development Goals (SDG)

2 Zero Hunger

12 Responsible Consumption and Production

REFERENCES

- Abdelatif, A.M., Elsayed, S.A. & Hassan, Y.M. (2010). Effect of state of hydration on body weight, Blood constituent and urine excretion in Nubian Goats (*Capra hircus*). *World Journal Of Agricultural Science*, 6: 178-188.
- Alamer, M. (2006). Physiological responses of Saudi Arabia indigenous goats to water deprivation. *Small Ruminant Research*, 63: 100–109.
- Ayantunde, A.A., Fernandez-rivera, S. & Dan-Gomma, A. (2008). Sheep fattening with groundnut haulms and millet bran in the West African Sahel, *Revue D'élevage Et De Médecine Vétérinaire Des Pays Tropicaux*, 61: 215-220.
- Balch, C.C., Balch, D.A., Johnson, V.W. & Turner, J. (1953). Factors affecting the utilization of food by dairy cows: The effect of limited water intake on the digestibility and rate of passage of hay. *British Journal of Nutrition*, 7(3): 212-224.
- Beede, D.K. (2009). Solving bad water problem for thirsty cows. *Journal Animal Production*, 11(13):217-227.
- Bohra, H.C. & Ghosh, P.K (1983). Nitrogen metabolism in water-restricted Marwari sheep of the Indian desert. *The Journal of Agricultural Science*, 101(3): 735-739.
- Casamassima, D., Pizzo, R., Palazzo, M., D'Alessandro, A.G. & Martemucci, G. (2008). Effect of water restriction on productive performance and blood parameters in Comisana sheep reared under intensive conditions. *Small Ruminant Research*, 78: 169-175
- Choshniak, I., Wittenberg, C., Rosenfeld, S. & Shkolnik, A. (1994). Rapid dehydration and kidney function in the black Bedouin goat. *Physiological Zoology*, 57(5): 573-579.
- Devendra, C. & McIeroy, G.B. (1982). Goat and sheep production in the tropics longman group. United kingdom, Limited England.
- Faires, F.C., Reagor, J.C., Sweeten, J.M. & Loneragan, G.H. (2007). Livestock Water Quality Standards. *Encyclopedia of Water Science*, 25: 172-179
- French, M.H. (1956). The effect of infrequent drinking on the consumption and digestibility of hay by zebu cattle Empire. *Journal Express Agriculture*, 24:128-136.
- Lardner, H.A., Kirychuk, B.D., Braul, L., Willms, W.D. & Yarotski, J. (2005). The effect of water quality on cattle performance on pasture. *Australian Journal of Agricultural Research*, 56(1): 97-104.
- Murphy, M.R. (1992). Water Metabolism of Dairy Cattle. *Journal Dairy Science*, 75:326–333.
- Riaz, M.Q., Sudekum, K.H., Clauss, M. & Jayanegara, A. (2014). Voluntary feed intake and digestibility of four domestic ruminant species as influenced by dietary constituents: A meta-analysis. *Livestock Science*, 162: 76-85
- SAS. (2000). Guide to personal computers, release 5.0 Statistical Analysis System Institute. Inclusion NC. North Carolina, USA.
- Toha, M.J.A., Boiling, L.D., Bunting & Dawson, K.A. (1987). Effect of water restriction and dietary sodium on nutrient metabolism in lambs. *Journal Animal Science*, 64(4): 55-57.

Investigation of the Effect of Seawater on the Fixation of Sheep Tissues with Formalin Fixation

Esin ÜNSALDI* 

Necmettin Erbakan University, Faculty of Veterinary Medicine, Department of Anatomy, Ereğli-Konya, Türkiye

Article Info	ABSTRACT
Received: 18.03.2026 Accepted: 06.07.2026 Online first: 21.07.2026 Published: 27.07.2026 Keywords: Distilled water, Ethanol, Formalin, Seawater, Sheep tissue fixation	This study investigated the effect of seawater as a diluent in formalin- and ethanol-based fixation solutions on the histological preservation of sheep tissues. Liver, heart, and spleen samples obtained from 40 sheep were fixed using six different solutions prepared with distilled water, seawater, or their combinations. Tissue samples (approximately 3 mm in thickness) were fixed for 24 hours at room temperature, followed by routine histological processing, sectioning at 4 µm, and hematoxylin and eosin (H&E) staining. Histological preservation was evaluated using a semi-quantitative scoring system, and the resulting scores were analyzed using appropriate statistical methods. Formalin-based fixatives demonstrated superior structural preservation compared to ethanol-based solutions. Among the formalin groups, seawater-containing solutions yielded the highest histological scores across all tissues. In contrast, ethanol-fixed tissues exhibited reduced structural integrity and lower preservation scores. These findings suggest that seawater can enhance the efficiency of formalin-based fixation and improve histological outcomes, offering a simple and cost-effective alternative to conventional diluents.

To cite this article:

Ünsaldı, E. (2026). Investigation of the Effect of Seawater on the Fixation of Sheep Tissues with Formalin Fixation, *Research and Practice in Veterinary and Animal Science (REPVAS)*, 3(2), 95-107.
<https://doi.org/10.69990/REPVAS.2026.3.2.4>

***Corresponding Author:** Esin Ünsaldı, esin.unsaldi@erbakan.edu.tr

INTRODUCTION

Tissue fixation is a fundamental step in histological and diagnostic studies as it preserves cellular and tissue structures in a state similar to their natural condition. This prevents autolysis and decay (Fox et al., 1985; Arnold et al., 1996; Kmiec, 2016; Karataş & Akcakavak, 2024; Kilinc & Oruc, 2024). Effective fixation maintains macroscopic tissue features and enables high-quality microscopic sectioning and staining, which are both essential for accurate histopathological evaluation. Inadequate fixation can produce artefacts that obscure cellular details, potentially leading to misinterpretation or erroneous diagnoses (Ajileye and Esan, 2022).

The efficiency of fixation is influenced by multiple factors, including pH, fixative concentration, temperature, osmolarity, exposure time, and tissue size (Freida, 2015; Singh et al., 2019). Common fixatives include aldehydes, oxidizing agents, and protein-denaturing chemicals (Thavarajah, 2012; Ekmen, 1992; Ünsaldı and Çiftçi, 2010). Formaldehyde (CH₂O), an aldehyde-based fixative, is most commonly used in a 10% formalin solution, which can preserve 2–3 mm thick tissue slices effectively within 24 hours (Bancroft and Gamble, 2008; Özdemir, 2016). Alcohol-based fixatives such as ethanol are also employed, although their slower tissue penetration may necessitate longer incubation periods (Braet and Ratinac, 2007; Rockey et al., 2009).

Although distilled water is the traditional diluent for fixatives, recent studies have suggested that seawater, due to its mineral and salt content, may improve fixation efficiency (Stowell, 1941; Titford and Horenstein, 2005; Bancroft and Gamble, 2008). However, systematic comparative studies evaluating seawater as a diluent in routine histological fixation remain scarce, particularly in formalin- and ethanol-based fixation solutions across different tissue types. Therefore, the present study aims to address this gap by systematically comparing the effects of seawater and distilled water as diluents on the histological preservation of sheep liver, heart, and spleen tissues.

MATERIAL and METHODS

Liver, heart, and spleen tissues were collected from sheep slaughtered for commercial food production at a licensed abattoir in Ankara, Türkiye. No animals were sacrificed specifically for this study, and no experimental procedures were performed on live animals. Therefore, ethical committee approval was not required in accordance with institutional and national regulations governing the use of slaughterhouse-derived tissues. The liver, heart, and spleen were selected because they represent structurally and functionally distinct parenchymal organs with different vascularity, cellular organization, and tissue architecture, allowing comparison of fixation quality across different tissue types. Fixative solutions were prepared separately for each sample using standard laboratory reagents obtained from commercial sources (Formalin: formaldehyde solution, ~37%, Germany; Alcohol: absolute ethanol, Isolab, Germany).

Six fixation solutions were prepared by combining formaldehyde or ethanol with varying ratios of distilled water and seawater, as described in Table 1. Seawater used in the preparation of selected fixation solutions was obtained from the Mediterranean coastline in the Hatay region of Türkiye. Following collection, the seawater was filtered to remove suspended particles and stored at room temperature until use. To reflect the typical salinity of Eastern Mediterranean seawater and to ensure consistency among all seawater-containing fixation solutions, salinity was adjusted to approximately 38‰ (38 ppt). The ionic composition was not determined analytically in the present study but was described based on the established physicochemical characteristics of Eastern Mediterranean seawater reported in the literature (Krom et al., 1991; Özsoy et al., 1993; Millero et al., 2006). The pH was measured at approximately 8.1, reflecting the typical slightly alkaline nature of Mediterranean seawater. Electrical conductivity ranged between 50 and 60 mS/cm, and density was approximately 1.025 g/cm³, both values consistent with reported characteristics of Eastern Mediterranean seawater.

Table 1. Composition and concentration ratios of fixatives

NBF	NBF 2	NBF 3
10% NBF	10% NBF	10% NBF
90% distilled water	0% distilled water	45% distilled water
0% seawater	90% seawater	45% seawater
EtOH 4	EtOH 5	EtOH 6
70% EtOH	70% EtOH	70% EtOH
30% distilled water	0% distilled water	15% distilled water
0% seawater	30% seawater	15% seawater

Note: The ratios of seawater and distilled water used in the preparation of NBF and EtOH solutions are presented (NBF= neutral buffered formalin; EtOH= ethanol).

The ionic composition was predominantly composed of sodium (Na^+) and chloride (Cl^-) ions, along with appreciable concentrations of magnesium (Mg^{2+}), calcium (Ca^{2+}), potassium (K^+), and sulfate (SO_4^{2-}). These ions play an important role in maintaining osmotic balance and may contribute to enhanced tissue preservation by reducing fixation-induced structural alterations. At the time of collection, seawater temperature ranged between 20 and 25°C, corresponding to typical environmental conditions of the Mediterranean coastal region. Overall, the physicochemical properties of the seawater used in this study were consistent with previously reported values for the Eastern Mediterranean (Krom et al., 1991; Millero et al., 2006; Özsoy et al., 1993).

The NBF 1 group (10% neutral buffered formalin diluted with 90% distilled water) was designated as the reference control, as it reflects the conventional fixation method widely accepted as the standard in routine histopathological applications.

Group classification was performed based on fixative category, tissue origin, and formulation of the fixation solutions to ensure consistency and traceability throughout the study. Formalin-containing groups were denoted as NBF (10% neutral buffered formalin), whereas ethanol-based groups were labeled as EtOH. Tissue abbreviations included L for liver, H for heart and S for spleen. Numerical codes ranging from 1 to 6 correspond to the specific solution compositions outlined in Table 1.

Tissue samples were assigned to groups according to the corresponding fixation solutions (Table 2).

Table 2. Tissue grouping and abbreviations for fixatives

Fixatives	Liver	Heart	Spleen
NBF 1	NBF L1	NBF H1	NBF S1
NBF 2	NBF L2	NBF H2	NBF S2
NBF 3	NBF L3	NBF H3	NBF S3
EtOH 4	EtOH L4	EtOH H4	EtOH S4
EtOH 5	EtOH L5	EtOH H5	EtOH S5
EtOH 6	EtOH L6	EtOH H6	EtOH S6

Note: NBF = neutral buffered formalin; EtOH = ethanol; L = Liver; H = Heart; S = Spleen.

1=10% NBF + 90% distilled water; 2=10% NBF + 90% seawater; 3=10% NBF + 45% distilled water +45% seawater; 4=70% EtOH + 30% distilled water; 5=70% EtOH + 30% seawater; 6=70% EtOH + 15% distilled water + 15% seawater

Each sample was trimmed to a uniform thickness of approximately 3 mm, immersed in the designated fixative, and maintained at room temperature for 24 hours. Following fixation, the tissues were rinsed under running tap water for 12 hours to remove residual fixative. Subsequently, the samples underwent routine histological processing, including dehydration through a graded alcohol series and clearing with xylene.

Paraffin-embedded tissues were sectioned at a thickness of 4 µm using a microtome. Sections were stained with hematoxylin and eosin (H&E) following standard protocols (Luna, 1968; Tuzcu et al., 2022; Akcakavak et al., 2023). Histological evaluation was performed using a Leica DM 2500 LED light microscope equipped with a Leica 170 HD digital imaging system (Singapore).

Histopathological assessment was conducted using a semi-quantitative scoring system adapted from Meyerholz et al. (2019). Six parameters—cellular integrity, nuclear detail, cytoplasmic staining, tissue architecture, shrinkage artifacts, and extracellular space expansion—were evaluated using a 4-point ordinal scale (0–3). Scores ranged from 0 (poor) to 3 (excellent), and the total score for each sample was calculated by summing individual parameter values, with higher scores indicating better preservation quality. The scoring criteria are presented in Table 3.

As the assumptions of parametric tests were not met, non-parametric methods were applied. Statistical analysis was performed using the Kruskal–Wallis test, followed by Dunn’s post hoc test for multiple comparisons. Histological scores are presented as mean ± standard error (SE) for descriptive purposes, in accordance with recommendations for statistical reporting in veterinary sciences (Selvi, 2024). The Kruskal–Wallis test compares groups based on mean ranks rather than arithmetic means; therefore, all statistical comparisons and significance levels were determined using rank-based analyses. All statistical analyses were performed using GraphPad Prism version 9 (GraphPad Software, USA). Statistical significance was set at *P < 0.05, **P < 0.01 and ***P < 0.001.

Table 3. Criteria used for semi-quantitative histopathological evaluation

Parameter	Score 0	Score 1	Score 2	Score 3
Cellular preservation	Extensive cellular disruption	Marked cellular alterations	Slight cellular changes	Intact cellular morphology
Nuclear clarity	Nuclei not discernible	Poor nuclear definition	Moderately distinguishable nuclei	Clearly defined nuclear structures
Cytoplasmic staining	Minimal or absent staining	Irregular staining pattern	Adequate staining intensity	Homogeneous and intense staining
Structural organization	Complete loss of tissue architecture	Partial disorganization	Largely preserved structure	Fully preserved architecture
Tissue shrinkage	Pronounced shrinkage artifacts	Moderate shrinkage	Minor shrinkage	No shrinkage observed
Interstitial space changes	Marked expansion	Moderate widening	Slight enlargement	No detectable change

Scoring definition:

- 0 = severe deterioration of tissue morphology
- 1 = evident structural alterations
- 2 = mild changes with largely preserved features
- 3 = optimal preservation with minimal or no artifacts

RESULTS

In this study, tissues from the liver, heart, and spleen tissues obtained from 40 sheep were immersed in different fixation solutions for 24 hours to evaluate the effectiveness of the fixatives. Four hours after immersion, during the trimming procedure, it was observed that the liver tissues in the NBF L1, NBF L2 and NBF L3 groups were easier to section than those in the EtOH L4, EtOH L5 and EtOH L6 groups. Four-micrometre-thick tissue sections were prepared and stained using the haematoxylin and eosin (H&E) method.

Liver Tissue

During trimming, liver tissues fixed in ethanol-based solutions were more difficult to section than those fixed in formalin-based solutions. Histological examination of haematoxylin and eosin

(H&E)-stained sections revealed clearer cellular morphology, as well as better preservation of hepatic cords and sinusoidal structures, in formalin-treated tissues than in ethanol-fixed samples (Figure 1).

Statistical evaluation demonstrated that the fixation efficiency of the NBF L1 group was significantly higher than that of the EtOH L6 group ($P < 0.01$). The NBF L2 group showed a highly significant increase in histological scores compared with the EtOH L6 group ($P < 0.001$). Additionally, the NBF L2 group demonstrated significantly higher scores than the EtOH L5 group ($P < 0.01$). Ethanol groups containing seawater (EtOH L5 and EtOH L6) showed lower histological scores compared to formalin-based fixatives (Table 4).

Figure 1. H&E staining appearance of sheep liver tissue in different fixation solutions (20× magnification). A. NBF L1; B. EtOH L4; C. NBF L2; D. EtOH L5; E. NBF L3; F. EtOH L6 (NBF: neutral buffered formalin, L: liver; 1: 10% formalin solution prepared with distilled water; 2: 10% formalin solution prepared with seawater; 3: 10% formalin solution prepared with a mixture of distilled water and seawater; EtOH: ethanol; 4: 70% EtOH with 30% distilled water; 5: 70% EtOH with 30% seawater; 6: 70% EtOH with 15% distilled water and 15% seawater).

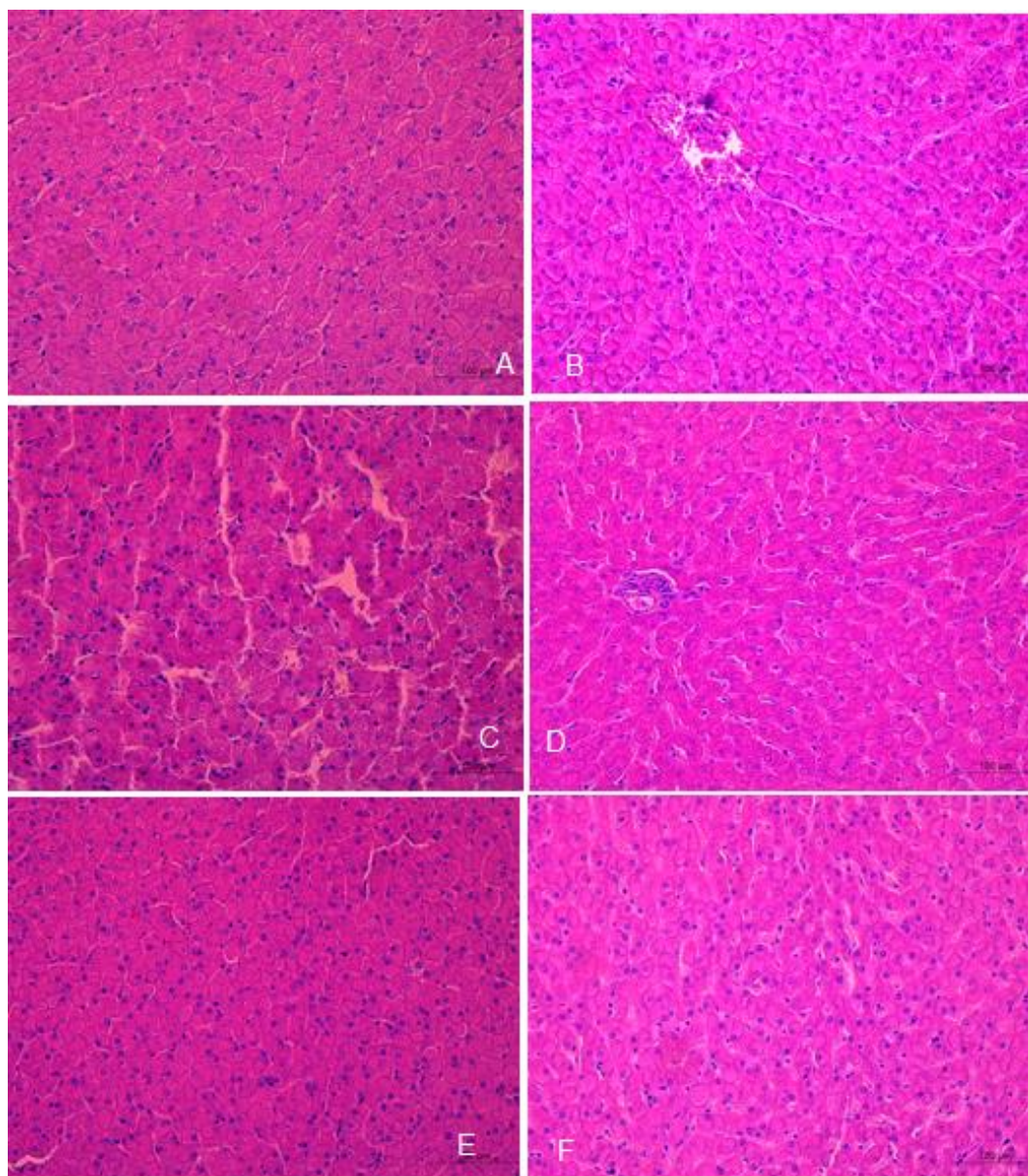


Table 4. Histological scores and statistical comparisons for liver, heart, and spleen tissues

Tissue	Fixative	Mean Histological Score $\pm$ SE	Statistical Significance vs. EtOH
Liver	NBF L1	8.2 $\pm$ 0.13	P < 0.01 vs. EtOH L6
	NBF L2	8.8 $\pm$ 0.10	P < 0.001 vs. EtOH L6; P < 0.01 vs. EtOH L5
	NBF L3	8.0 $\pm$ 0.17	NS
	EtOH L4	6.1 $\pm$ 0.20	–
	EtOH L5	6.3 $\pm$ 0.17	–
	EtOH L6	5.8 $\pm$ 0.13	–
Heart	NBF H1	8.0 $\pm$ 0.13	P < 0.05 vs. EtOH H6
	NBF H2	8.5 $\pm$ 0.10	P < 0.01 vs. EtOH H4/H5
	NBF H3	8.1 $\pm$ 0.17	NS
	EtOH H4	6.2 $\pm$ 0.13	–
	EtOH H5	6.4 $\pm$ 0.10	–
	EtOH H6	5.9 $\pm$ 0.17	–
Spleen	NBF S1	8.0 $\pm$ 0.13	P < 0.05 vs. EtOH S6
	NBF S2	8.6 $\pm$ 0.10	P < 0.001 vs. EtOH S6; P < 0.01 vs. EtOH S5; P < 0.05 vs. EtOH S4
	NBF S3	8.1 $\pm$ 0.17	P < 0.05 vs. EtOH S6
	EtOH S4	6.0 $\pm$ 0.13	–
	EtOH S5	6.3 $\pm$ 0.17	–
	EtOH S6	5.7 $\pm$ 0.10	–

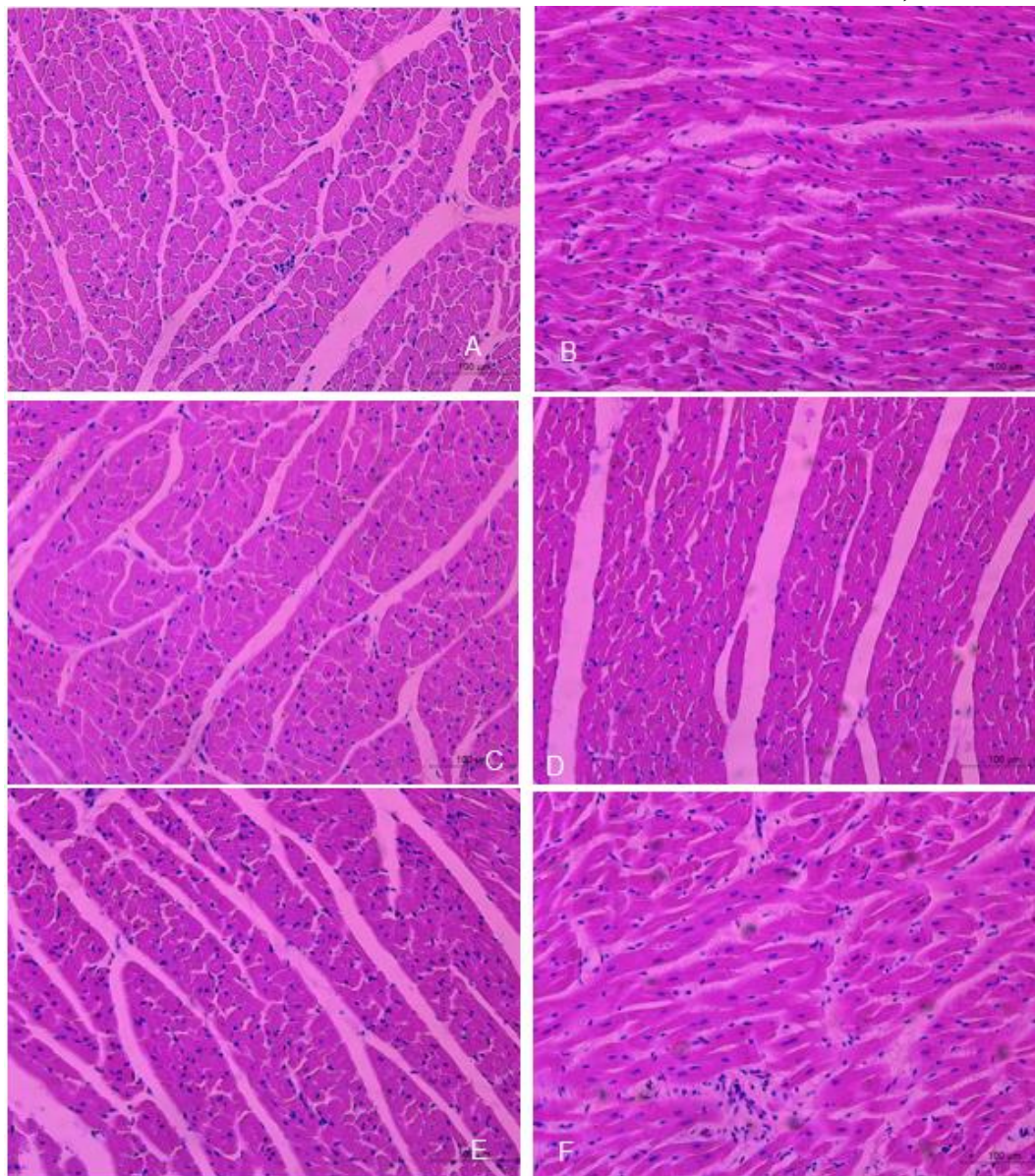
Note: Histological scores were obtained using the semi-quantitative scoring system described by Meyerholz et al. (2009). Data are presented as mean $\pm$ standard error (SE) for descriptive purposes. As the assumptions of parametric tests were not met, statistical comparisons were performed using the Kruskal–Wallis test followed by Dunn’s post hoc test. Because the Kruskal–Wallis test is based on rank comparisons, all statistical inferences and reported P values were derived from rank-based analyses rather than arithmetic means. NBF = neutral buffered formalin; EtOH = ethanol; L = liver; H = heart; S = spleen.

Heart Tissue

Compared with ethanol-based fixatives, heart tissues fixed with NBF-based solutions demonstrated improved handling characteristics during trimming and superior preservation of myocardial architecture. Histological evaluation confirmed greater tissue integrity and improved staining quality in formalin-treated samples (Figure 2).

Statistical analysis revealed a significant difference between the NBF H1 and EtOH H6 groups (P < 0.05). Furthermore, the NBF H2 group demonstrated significantly higher preservation scores than the EtOH H4 and EtOH H5 groups (P < 0.01) (Table 4).

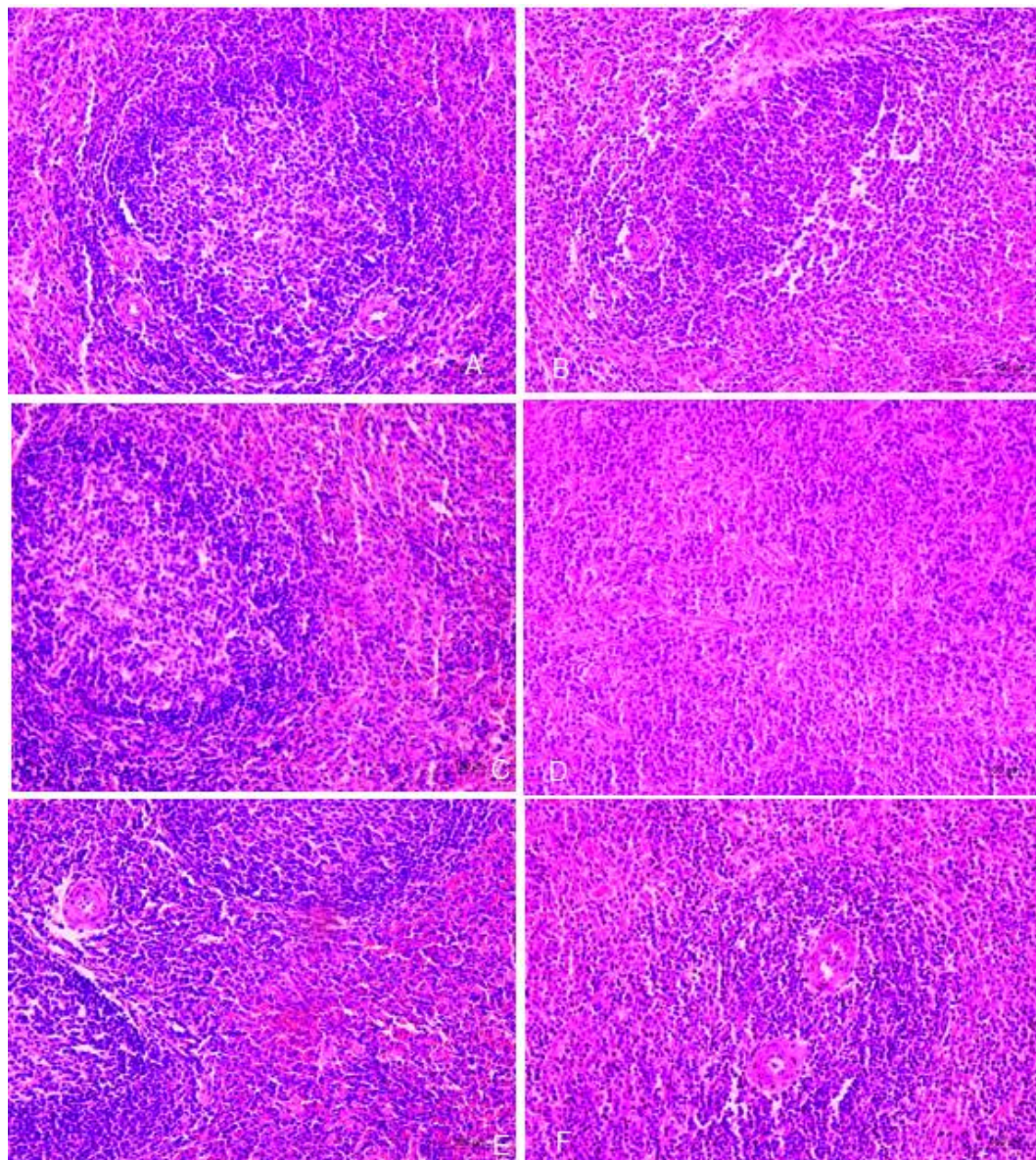
Figure 2. H&E staining appearance of sheep heart tissue in different fixation solutions (20× magnification). A. NBF H1; B. EtOH H4; C. NBF H2; D. EtOH H5; E. NBF H3; F. EtOH H6. (NBF: neutral buffered formalin; H: heart; 1: 10% formalin solution prepared with distilled water; 2: 10% formalin solution prepared with seawater; 3: 10% formalin solution prepared with a mixture of distilled water and seawater; EtOH: ethanol; 4: 70% EtOH with 30% distilled water; 5: 70% EtOH with 30% seawater; 6: 70% EtOH with 15% distilled water and 15% seawater).



Spleen Tissue

Spleen tissues fixed in formalin solutions were firmer during trimming and showed better preservation of splenic architecture, including clearly distinguishable red and white pulp regions, than ethanol-fixed tissues (Figure 3).

Figure 3. H&E staining appearance of sheep spleen tissue in different fixation solutions (20× magnification). A. NBF S1, B. EtOH S4; C. NBF S2, D. EtOH S5; E. NBF S3; F. EtOH S6. (NBF: neutral buffered formalin; S: spleen; 1: 10% formalin solution prepared with distilled water; 2: 10% formalin solution prepared with seawater; 3: 10% formalin solution prepared with a mixture of distilled water and seawater; EtOH: ethanol; 4: 70% EtOH with 30% distilled water; 5: 70% EtOH with 30% seawater; 6: 70% EtOH with 15% distilled water and 15% seawater).



Statistical evaluation revealed that the NBF S1 group had significantly higher scores than the EtOH S6 group ($P < 0.05$). The NBF S2 group showed highly significant differences compared to the EtOH S6 group ($P < 0.001$), as well as significant differences compared to the EtOH S5 and EtOH S4 groups ($P < 0.01$ and $P < 0.05$, respectively). Furthermore, the NBF S3 group demonstrated improved fixation quality compared to the EtOH S6 group ($P < 0.05$) (Table 4).

Overall, seawater-containing formalin solutions, particularly the NBF 2 groups, showed higher histological preservation scores across liver, heart, and spleen tissues than ethanol-based fixation solutions, indicating a generally favorable effect of seawater on tissue fixation quality.

DISCUSSION

Effective tissue fixation is essential for preserving structural integrity and preventing autolysis, thereby ensuring a reliable histological evaluation. Previous studies have highlighted differences in the efficiency of fixation between formalin- and alcohol-based fixatives. For example, Haque et al. (2020) compared the fixation of liver, brain, and spleen tissues for 24 hours using alcohol-based fixatives and formalin. They found that alcohol fixation preserved cytoplasmic details and overall tissue morphology better than formalin fixation, which occasionally resulted in structural alterations. Similarly, Rahman et al. (2022) concluded that, for certain tissue types, alcohol-based fixatives could serve as a superior alternative to formalin, particularly for preserving delicate structures and minimising fixation artefacts. In contrast to these reports, the present study demonstrated superior histological preservation with formalin-based fixatives after 24 hours of fixation. Formalin-treated tissues exhibited faster and more complete fixation, maintained structural details more effectively, and were easier to trim, whereas tissues fixed with 70% ethanol were softer and showed minor microvoid formation, likely due to lipid extraction. This discrepancy may be explained by differences in tissue type, fixation duration, ethanol concentration, and experimental protocols. Although ethanol fixation did not leave dye residues in the tissues, a longer exposure time was required to achieve comparable preservation. These findings are consistent with previous reports indicating that alcohol-based fixation generally requires longer incubation periods to achieve fixation quality comparable to that of formalin (Fox et al., 1985; Harper et al., 1985).

It has been reported that the high ionic strength of seawater, mainly due to sodium (Na^+) and chloride (Cl^-) ions, contributes to maintaining osmotic balance between extracellular and intracellular compartments, thus limiting cellular swelling or shrinkage during fixation (Kmieć, 2016; Bancroft & Gamble, 2008). In this study, the use of seawater as a diluent for formalin significantly improved tissue preservation. The improved fixation observed in seawater-based formalin solutions can be explained by the physicochemical properties of seawater.

In contrast, distilled water lacks ionic content and can create a hypotonic environment, potentially leading to osmotic stress and structural degradation. Furthermore, the presence of divalent ions such as calcium (Ca^{2+}) and magnesium (Mg^{2+}) can further stabilize cellular membranes and protein structures by regulating electrostatic interactions and reducing excessive protein denaturation. These ions can also enhance tissue integrity by promoting smoother cross-linking during formaldehyde fixation (Fox et al., 1985; Titford, 2009). Consistent with the literature, the results of the present study demonstrated that seawater-based dilutions may facilitate improved penetration and fixation efficiency compared with distilled water.

It has been reported that pH is an important factor influencing fixation efficiency, formaldehyde stability, protein cross-linking reactions, and staining quality (Kmieć, 2016; Bancroft and Gamble, 2008). Seawater typically has a slightly alkaline pH, whereas distilled water is closer to neutral. In the present study, the improved fixation quality observed in seawater-based formalin solutions may therefore be partly associated with the slightly alkaline nature of seawater. This pH-related effect, together with the ionic composition of seawater, may have contributed to better tissue preservation and improved histological appearance compared with distilled water-based solutions.

In addition to these physicochemical effects, the tissue-specific differences observed in the present study may also be related to the structural characteristics of each organ. The liver has a highly vascular and parenchymatous architecture, the heart contains dense and regularly arranged muscle fibers, and the spleen has a delicate lymphoid and vascular organization. Therefore, the response of these tissues to different fixative solutions may vary depending on cellular density, extracellular matrix composition, and vascular spaces, as previously reported in the literature (Bancroft and

Gamble, 2008; Freida, 2015; Kmiec, 2016). In this context, the better preservation observed in seawater-containing formalin groups suggests that seawater may contribute not only to osmotic stabilization but also to more uniform fixation across tissues with different histological architectures. This may be particularly useful in routine anatomical and histological studies where multiple tissue types are processed under the same fixation conditions. Solutions of NBF prepared with seawater outperformed those diluted with distilled water, suggesting that the salt and mineral content of seawater may enhance the penetration of formaldehyde or influence the osmotic balance, thereby facilitating more efficient fixation (Stowell, 1941; Titford and Horenstein, 2005; Bancroft and Gamble, 2008). This is consistent with the findings of Stowell (1941), who reported that isotonic saline improved the dilution of formalin for rabbit kidney tissues and reduced tissue swelling. By systematically comparing distilled water and seawater dilutions, this study provides evidence to support the potential benefits of using seawater as an alternative fixative diluent, a topic that has received limited attention in the existing literature.

Previous studies have reported that appropriate fixative composition and ionic conditions play an important role in preserving tissue architecture and minimizing fixation-related artifacts (Stowell, 1941; Titford and Horenstein, 2005; Bancroft and Gamble, 2008). Consistent with these reports, histological scoring in the present study demonstrated that seawater-containing neutral buffered formalin consistently produced higher preservation scores than formalin diluted with distilled water or ethanol-based solutions. Red and white pulp structures in the spleen, myocardial architecture in the heart, and hepatocyte morphology in the liver were all better preserved in the seawater-containing formalin groups. Statistical analysis confirmed these observations, revealing significant differences ($P < 0.05$ to $P < 0.001$) between the seawater-enhanced formalin groups and their counterparts.

The slower fixation rate observed in alcohol in this study is consistent with previous reports indicating that alcohol attracts intracellular water, resulting in tissue shrinkage and potential microstructural alterations (Harper et al., 1985). Xu and Rogers (1993) demonstrated the presence of residual formaldehyde in fish tissues up to 72 hours after treatment. In contrast, ethanol fixation leaves no chemical residues, which emphasises alcohol's suitability in contexts where residual aldehydes must be minimised. In this study, however, ethanol fixation at a concentration of 70% was insufficient to fully stabilise the tissues within 24 hours, suggesting that longer incubation periods are necessary to achieve comparable histological quality.

The relatively lower fixation performance observed in ethanol-based groups may be attributed to its mechanism of action. Ethanol induces protein coagulation primarily through dehydration, which can result in tissue shrinkage and the formation of microstructural artifacts (Bancroft & Gamble, 2008; Kmiec, 2016). In addition, its penetration characteristics differ from those of formaldehyde, potentially leading to less uniform fixation within the tissue matrix (Fox et al., 1985). Previous studies have reported that alcohol-based fixatives may require longer exposure times to achieve comparable structural preservation, particularly in thicker tissue samples (Titford, 2009). These findings are consistent with the present study, in which 70% ethanol was insufficient to ensure optimal fixation within 24 hours.

Overall, the present findings have several practical implications for routine histological practice. Formalin remains the faster and more robust fixative for routine histological studies, particularly when rapid processing is required. Incorporating seawater into formalin solutions could improve fixation efficiency and tissue preservation, offering a cost-effective and easily accessible alternative to standard distilled water dilutions. Although slower, alcohol-based fixatives offer the advantage of leaving no reactive residues and may be preferable in situations where chemical interference must be minimised.

To our knowledge, this is one of the first studies to systematically evaluate the use of seawater as a diluent in the formalin fixation of sheep tissues. Direct comparisons between the present findings

and previous studies remain limited because experimental investigations specifically evaluating seawater as a formalin diluent are scarce. Therefore, the discussion of the present findings was primarily based on established physicochemical principles of tissue fixation and on studies addressing formalin fixation, saline-based diluents, and alcohol-based fixatives. Future studies should investigate different seawater concentrations, additional tissue types, longer fixation periods, and the chemical interactions between seawater ions and formaldehyde molecules to enable more comprehensive comparisons and to clarify the mechanisms underlying improved fixation efficiency.

One limitation of this study is that it only evaluated the effects of fixation at the 24-hour time point. Future studies including longer fixation durations and additional tissue types would clarify the applicability of seawater-based dilutions further.

CONCLUSION

In conclusion, formalin-based fixatives remain superior in terms of fixation speed and structural preservation. The incorporation of seawater as a diluent improved histological preservation and fixation quality in formalin-based fixation groups compared with distilled water and ethanol-based fixation solutions. Although ethanol-based solutions require longer incubation periods to achieve comparable results, they offer the advantage of minimizing chemical residues. These findings provide practical insights for routine histological applications and suggest that the use of seawater represents a simple, cost-effective strategy to improve fixation quality in laboratory settings. This approach may be particularly useful in resource-limited laboratories and during field necropsies where access to conventional laboratory-grade diluents may be limited.

Acknowledgements

The author sincerely thanks everyone who contributed to the successful completion of this study for their valuable support and assistance.

Ethics Approval

Liver, heart, and spleen tissues were collected from sheep slaughtered for commercial food production at a licensed abattoir in Ankara, Türkiye. No animals were sacrificed specifically for this study, and no experimental procedures were performed on live animals. Therefore, ethical committee approval was not required in accordance with institutional and national regulations governing the use of slaughterhouse-derived tissues.

Funding

There is not any funding in this study

Conflict of Interest

Authors declare that there is no conflict of interest.

Author Contributions

Research Design (CRediT 1) Author (%100)

Data Collection (CRediT 2) Author (%100)

Research - Data analysis - Validation (CRediT 3-4-6-11) Author (%100)

Writing the Article (CRediT 12-13) Author (%100)

Revision and Improvement of the Text (CRediT 14) Author (%100)

Sustainable Development Goals (SDG)

3 Good Health and Well-Being

REFERENCES

- Ajileye, A.B. & Esan, E.O. (2022). Fixation and fixatives in histopathology: a review. *Bayero Journal of Pure and Applied Sciences*, 15(1): 231-243. <https://doi.org/10.4314/bajopas.v15i1.32>
- Akcakavak, G., Tuzcu, M., Tuzcu, N., Celik, Z., Tural, A. & Dagar, O. (2023). Investigation with Real-Time PCR and Histopathology on the presence of *H. felis*, *H. heilmannii* and *H. pylori* in dogs. *Revista Científica de la Facultad de Veterinaria*, 33(1): 1-7. <https://doi.org/10.52973/rcfcv-e33214>
- Arnold, M.M., Srivastava, S., Fredenburgh, J., Stockard, C.R., Myers, R.B. & Grizzle, W.E. (1996). Effects of fixation and tissue processing on immunohistochemical demonstration of specific antigens. *Biotechnic & Histochemistry*, 71(5): 224-230. <https://doi.org/10.3109/10520299609117164>
- Bancroft, J.D. & Gamble, M. (2008). Theory and practice of histological techniques. In: Bancroft JD, Gamble M (editors). *Theory and Practice of Histological Techniques*. 6th ed. Philadelphia, PA, USA: Churchill Livingstone Elsevier; 2008. pp. 44
- Braet, F. & Ratnac, K. (2007). Creating next-generation microscopists: Structural and molecular biology at the crossroads. *Journal of Cellular and Molecular Medicine*, 11(4): 759-763. <https://doi.org/10.1111/j.1582-4934.2007.00072.x>
- Ekmen, F. (1992). Immunoenzim tekniklerin histopatoloji'ye uygulanması, *Etlik Veteriner Mikrobiyoloji Dergisi*, 7(3): 33-50.
- Fox, C.H., Johnson, F.B., Whiting, J. & Roller P.P. (1985). Formaldehyde fixation. *Journal of Histochemistry and Cytochemistry*, 33(8): 845-853. <https://doi.org/10.1177/33.8.3894502>
- Freida, L.C. (2015). Histotechnology: A Self-Instructional Text. 4th ed. Hong Kong, China: ASCP Press. pp. 265.
- Haque, Z., Rahman, M.A., Khan, M.Z.I., et al. (2020). Alcohol-based fixatives can better preserve tissue morphology than formalin. *International Journal of Morphology*, 38(5): 1371-1375. <https://doi.org/10.4067/S0717-95022020000501371>
- Harper, C.G., Kril, J.J. & Holloway, R.L. (1985). Brain shrinkage in chronic alcoholics: a pathological study. *British Medical Journal*, (Clin Res Ed), 290(6467): 501-504. <https://doi.org/10.1136/bmj.290.6467.501>
- Karataş, O. & Akçakavak, G. (2024). Evaluation of local expressions of acute phase proteins in white muscle disease in lambs by the immunohistochemical method. *Revista Científica de la Facultad de Ciencias Veterinarias*, 34(1): 1-7. <https://doi.org/10.52973/rcfcv-e34313>
- Kilinc, B. & Oruc, E. (2024). Pathological and biochemical investigation of the effects of *Silybum marianum* against Methomyl damage in broiler liver. *Revista Científica de la Facultad de Ciencias Veterinarias*, 34(2): e34375. <https://doi.org/10.52973/rcfcv-e34375>
- Kmieć, Z. (2016). [Rec.] J.A. Kiernan. Histological and Histochemical Methods: Theory and Practice. 5th ed. Scion Publishing: London, UK. <https://doi.org/10.5603/FHC.a2016.0007>
- Krom, M.D., Kress, N., Brenner, S. & Gordon, L.I. (1991). Phosphorus limitation of primary productivity in the eastern Mediterranean Sea. *Limnology and Oceanography*, 36(3): 424-432. <https://doi.org/10.4319/lo.1991.36.3.0424>

- Luna, L.G. (1968). Manual of histologic staining methods. In: McGraw-Hill (3rd ed.). Washington, DC, USA: Armed Forces Institute of Pathology.
- Meyerholz, D.K., Griffin, M.A., Castilow, E.M., Varga, S.M. & Beck, A.P. (2009). Comparison of histochemical methods for murine eosinophil detection in an RSV vaccine-enhanced inflammation model. *Toxicologic Pathology*, 37(2): 249-255. <https://doi.org/10.1177/0192623308329342>
- Millero, F.J., Feistel, R., Wright, D.G. & McDougall, T.J. (2008). The composition of Standard Seawater and the definition of the Reference-Composition Salinity Scale. Deep-Sea Research Part I: *Oceanographic Research Papers*, 55(1): 50–72. <https://doi.org/10.1016/j.dsr.2007.10.001>
- Özdemir, Ü. (2016). Doymuş tuzlu (NaCl) su çözeltisinin doku tespit işleminde kullanımının araştırılması. Master's Thesis, Selcuk University, Konya, Türkiye.
- Özsoy, E., Hecht, A., Ünlüata, Ü., et al. (1993). A synthesis of the Levantine Basin circulation and hydrography, 1985–1990. Deep-Sea Research Part II: *Topical Studies in Oceanography*, 40(6): 1075–1119. [https://doi.org/10.1016/0967-0645\(93\)90063-S](https://doi.org/10.1016/0967-0645(93)90063-S)
- Rahman, M.A., Sultana, N., Ayman, U., et al. (2022). Alcoholic fixation over formalin fixation: A new, safer option for morphologic and molecular analysis of tissues. *Saudi Journal of Biological Sciences*, 29(1): 175-182. <https://doi.org/10.1016/j.sjbs.2021.08.075>
- Rockey, D.C., Caldwell, S. H., Goodman, Z. D., Nelson, R. C. & Smith, A. D. (2009). Liver biopsy. *Hepatology*, 49(3): 1017-1044. <https://doi.org/10.1002/hep.22742>
- Selvi, M.H. (2024). The use of statistics in veterinary sciences and the test methods used. *Research and Practice in Veterinary and Animal Science (REPVAS)*, 1(1): 43-50. <https://doi.org/10.69990/repvas.2024.1.1.6>
- Singh, H., Bishen, K.A., Garg, D., Sukhija, H., Sharma, D. & Tomar, U. (2019). Fixation and fixatives: Roles and functions—A short review. *Dental Journal of Advance Studies*, 7(2): 51-55. <https://doi.org/10.1055/s-0039-1693098>
- Stowell, R.E. (1941). Effect on tissue volume of various methods of fixation, dehydration, and embedding. *Stain Technology*, 6(2): 67-83. <https://doi.org/10.3109/10520294109106200>
- Thavarajah, R., Mudimbaimannar, V.K., Elizabeth, J., Rao, U.K. & Ranganathan, K. (2012). Chemical and physical basics of routine formaldehyde fixation. *Journal of Oral and Maxillofacial Pathology*, 16(3): 400-405. <https://doi.org/10.4103/0973-029X.102496>
- Titford, M.E. & Horenstein, M.G. (2005). Histomorphologic assessment of formalin substitute fixatives for diagnostic surgical pathology. *Dental Journal of Advanced Studies*, 129(4): 502-506. <https://doi.org/10.5858/2005-129-502-HAOFSE>
- Titford, M. (2009). Progress in the development of microscopical techniques for diagnostic pathology. *Journal of Histotechnology*, 32(1): 9-19. <https://doi.org/10.1179/his.2009.32.1.9>
- Tuzcu, M., Tuzcu, N., Akçakavak, G., Eryavuz, A., Özsoy, Ş.Y. & Oruc, E. (2022). Diagnosis of *Sarcina ventriculi*-derived haemorrhagic abomasitis in lambs by histopathology and real-time PCR. *Acta Veterinaria Brno*, 91(3): 227-233. <https://doi.org/10.2754/avb202291030227>
- Ünsaldı, E. & Çiftçi, M.K. (2010). Formaldehit, kullanım alanları, risk grubu, zararlı etkileri ve koruyucu önlemler. *Yüzüncü Yıl Üniversitesi Veteriner Fakültesi Dergisi*, 21(1): 71-75.
- Xu, D. & Rogers, W.A. (1993). Formaldehyde residue in striped bass muscle. *Journal of Aquatic Animal Health*, 5(4): 306-312. [https://doi.org/10.1577/1548-8667\(1993\)005<0306:FRISBM>2.3.CO;2](https://doi.org/10.1577/1548-8667(1993)005<0306:FRISBM>2.3.CO;2)

An Exploratory Observational Study of Rearing Behaviour in Horses

Yavuzkan PAKSOY ^{1*}, Ömer Barış İNCE ², Nazan KOLUMAN ³

¹Çukurova University, Ceyhan Faculty of Veterinary Medicine, Department of Animal Science, Adana, Türkiye

²Necmettin Erbakan University, Faculty of Veterinary Medicine, Department of Virology, Konya, Türkiye

³Çukurova University, Faculty of Agriculture, Department of Animal Science, Adana, Türkiye

Article Info	ABSTRACT
Received: 23.05.2026 Accepted: 11.07.2026 Online first: 21.07.2026 Published: 27.07.2026 Keywords: Equine welfare, Exploratory observational study, Horse behaviour, Management, Rearing.	Rearing is a behaviour in which a horse stands on its hind limbs while lifting its forelimbs off the ground. Although it can occur as part of the normal behavioural repertoire, repeated or contextually inappropriate rearing may compromise horse welfare and rider safety. This exploratory observational study described horses with and without reported rearing behaviour on horse farms in Adana, Mersin and Konya, Türkiye. Data were collected for 80 horses through farm records, semi-structured interviews with owners, consultations with farm veterinarians and observations in stables and paddocks. The study included 59 horses with reported rearing behaviour and 21 horses without reported rearing behaviour. The sample comprised 32 Thoroughbreds, 24 Arabians, 16 Belgian horses and 8 ponies. The observations underline the importance of evaluating potential health problems, management conditions, training practices and rider-horse interactions when a horse exhibits rearing behaviour. Differences in distributions were observed for sex (exact $p=0.004$; Holm-adjusted $p=0.014$), intended use (exact $p<0.001$; Holm-adjusted $p<0.001$) and recorded health status (exact $p=0.003$; Holm-adjusted $p=0.014$). No evidence of distributional differences was observed for breed (exact $p=0.436$; Holm-adjusted $p=0.873$) or age (exact $p=0.444$; Holm-adjusted $p=0.873$). Health problems were recorded in eight horses overall: two of the 59 horses with reported rearing behaviour and six of the 21 horses without reported rearing behaviour. Limited field-based information is available regarding the characteristics of horses exhibiting rearing behaviour in Türkiye. Therefore, the present exploratory observational study aimed to describe horses with and without reported rearing behaviour and to provide a basis for future analytical studies. Further studies with larger, prospectively selected samples and standardised behavioural assessments are required to identify factors associated with rearing behaviour.

To cite this article:

Paksoy, Y., İnce, Ö. B., Koluman, N. (2026). An Exploratory Observational Study of Rearing Behaviour in Horses, *Research and Practice in Veterinary and Animal Science (REPVAS)*, 3(2), 108-115.
<https://doi.org/10.69990/REPVAS.2026.3.2.5>

*Corresponding Author: Yavuzkan Paksoy, yavuzkan7@gmail.com

INTRODUCTION

The invention of technological tools has caused horses to lose their working characteristics. Nowadays, they are primarily bred for racing and sports (Hacan et al., 2018; Paksoy et al., 2026). Under appropriate care and feeding conditions, horses demonstrate their true performance. However, when appropriate management strategies are not implemented, or when any health problems arise, horses may exhibit abnormal behavior. This abnormal behavior can reduce the horse's performance. Among these abnormal behaviors, frequent rearing is considered a significant fault in horse breeding (Gücüyener Hacan and Akçapınar, 2013; Paksoy and Gücüyener Hacan, 2023; Yalçın, 2009). To achieve optimal productivity, horses must be bred well, and this is only possible if they are healthy and in a peaceful environment. Proper care and feeding are essential for the health of horses. Routine practices such as regular grooming, hoof care and stable cleaning are vital (Arabacı, 2018; Paksoy and Ünal, 2010).

The nutritional needs of horses are affected by whether they are bred for hobby, sport or racing purposes. Their carbohydrate and protein requirements vary depending on how they are used (Şehu, 1997). The conditions in which horses live determine their welfare level. Conversely, behaviour is a parameter that provides information about the welfare level of horses (Waran, 2007). Behaviour is defined as the responses of animals to stimuli from their environment. If these responses are in the horse's nature, they are called 'normal behaviour'. Examples of normal behaviours include imitation, forming friendships, feeding, reproduction, resting, sleeping and playing (Paksoy & Koluman, 2025; Paksoy et al., 2025). From a breeding perspective, these are beneficial behaviours that should be present. Abnormal behaviours, on the other hand, are generally acquired behaviours that are very difficult to abandon. They can lead to serious financial and moral losses from a breeding perspective and are considered defects. Examples of abnormal behaviours include chewing wood, wind-swallowing, head-bobbing, hitting walls, biting and spinning around (Gücüyener Hacan and Akçapınar, 2013; Paksoy and Gücüyener Hacan, 2023; Yalçın, 2009).

Limited field-based information is available regarding the characteristics of horses exhibiting rearing behaviour in Türkiye. Therefore, the present exploratory observational study aimed to describe horses with and without reported rearing behaviour and to provide a basis for future analytical studies.

MATERIAL and METHODS

Ethical Approval

This study was evaluated by the Ethics Committee of Çukurova University, Ceyhan Faculty of Veterinary Medicine, and approved as ethically appropriate (Decision No: 2-4, Date: 13.02.2026).

Sample design and animals

This exploratory observational study was conducted on horse farms in the provinces of Adana, Mersin and Konya, Türkiye. A total of 80 horses of different ages and breeds were included. The sample comprised 32 Thoroughbreds, 24 Arabians, 16 Belgian horses and eight ponies. Based on owner reports and field observations, 59 horses were classified as exhibiting rearing behaviour and 21 horses were classified as not exhibiting rearing behaviour. The study was designed as a descriptive field assessment and was not intended to estimate population prevalence or establish causality. Horses were included using a convenience sampling approach from participating farms. Therefore, the proportion of horses exhibiting rearing behaviour in the study sample should not be interpreted as a prevalence estimate for the wider horse population.

Rearing Behavior: A horse was considered to have exhibited rearing behavior if it lifted its two front legs into the air and stood on its two hind legs. The duration of time it stood on its hind legs was not considered.

Data Collection

Information on age, sex, coat colour and breed was obtained from available farm and pedigree records. The intended use of the horses and behavioural observations were recorded through semi-structured interviews with owners. Researchers also observed the horses in stables and paddocks at specified intervals. Information on health status was obtained through consultation with veterinarians responsible for the participating farms.

Statistical Analysis

Data were entered into Microsoft Excel and summarised descriptively. Given the exploratory nature of the study and the small number of observations in several categories, exact tests were used for selected categorical variables. Two-sided Fisher's exact tests were applied to 2×2 tables (age, sex and health status), whereas Fisher–Freeman–Halton exact tests were used for larger contingency tables (breed and intended use). Because five exploratory exact tests were performed, Holm's method was used to adjust p-values for multiple testing. Exact and Holm-adjusted p-values are reported. No regression models were fitted. These analyses were univariable, unadjusted and hypothesis-generating; they do not account for confounding, the unmatched group structure, convenience sampling or farm-level clustering and should not be interpreted as evidence of causality, independent risk factors or population-level prevalence estimates.

RESULTS

A total of 80 horses were included in the study. Of these, 59 (73.8%) were classified as exhibiting rearing behaviour and 21 (26.3%) as not exhibiting rearing behaviour. Breed distribution is shown in Table 1, and additional descriptive characteristics, including age, sex, intended use and health status, are presented in Table 2. Exploratory exact-test results are summarised in Table 3. Differences in distributions were observed for sex (exact $p=0.004$; Holm-adjusted $p = 0.014$), intended use (exact $p<0.001$; Holm-adjusted $p<0.001$) and recorded health status (exact $p = 0.003$; Holm-adjusted $p=0.014$). No evidence of distributional differences was observed for breed (exact $p=0.436$; Holm-adjusted $p=0.873$) or age (exact $p=0.444$; Holm-adjusted $p=0.873$). Health problems were recorded in eight horses overall: two of the 59 horses with reported rearing behaviour and six of the 21 horses without reported rearing behaviour. These exact comparisons are exploratory and unadjusted for confounding and should not be interpreted as causal or population-level effects.

Table 1. Breed distribution by rearing status

Breed	Total n (%)	Rearing behaviour present n (%)	Rearing behaviour absent n (%)
Thoroughbred	32 (40.0)	26 (44.1)	6 (28.6)
Arabian	24 (30.0)	18 (30.5)	6 (28.6)
Belgian horse	16 (20.0)	10 (16.9)	6 (28.6)
Pony	8 (10.0)	5 (8.5)	3 (14.3)
Total	80 (100.0)	59 (100.0)	21 (100.0)

Note: Percentages in the “Total” column were calculated using the total sample size as the denominator (n = 80). Percentages in the “Rearing behaviour present” column were calculated using the number of horses with reported rearing behaviour as the denominator (n = 59). Percentages in the “Rearing behaviour absent” column were calculated using the number of horses without reported rearing behaviour as the denominator (n = 21). These values describe the selected study sample only and should not be interpreted as breed-specific prevalence estimates, population-level prevalence estimates or evidence of associations.

Table 2. Descriptive characteristics by rearing status

Variable	Category	Total n (%)	Rearing behaviour present n (%)	Rearing behaviour absent n (%)
Age	≤3 years	35 (43.8)	24 (40.7)	11 (52.4)
	>3 years	45 (56.3)	35 (59.3)	10 (47.6)
Sex	Female	35 (43.8)	20 (33.9)	15 (71.4)
	Male	45 (56.3)	39 (66.1)	6 (28.6)
Intended use	Racing	30 (37.5)	26 (44.1)	4 (19.0)
	Sport/show	40 (50.0)	32 (54.2)	8 (38.1)
	Hobby/recreational	10 (12.5)	1 (1.7)	9 (42.9)
Health status	No recorded health problem	72 (90.0)	57 (96.6)	15 (71.4)
	Recorded health problem	8 (10.0)	2 (3.4)	6 (28.6)

Note: Percentages in the “Total” column were calculated using the total sample size as the denominator (n = 80). Percentages in the “Rearing behaviour present” column were calculated using the number of horses with reported rearing behaviour as the denominator (n = 59). Percentages in the “Rearing behaviour absent” column were calculated using the number of horses without reported rearing behaviour as the denominator (n = 21). These values are descriptive only and should not be interpreted as prevalence estimates, evidence of associations or causal relationships.

Table 3. Exploratory exact tests by rearing status

	Exact test	Exact p-value	Holm-adjusted p-value
Breed	Fisher–Freeman–Halton exact test	0.436	0.873
Age	Fisher’s exact test	0.444	0.873
Sex	Fisher’s exact test	0.004	0.014
Intended use	Fisher–Freeman–Halton exact test	<0.001	<0.001
Health status	Fisher’s exact test	0.003	0.014

Note: Two-sided Fisher’s exact tests were used for 2 × 2 tables (age, sex and health status), and Fisher–Freeman–Halton exact tests were used for larger contingency tables (breed and intended use). Holm-adjusted p-values account for the five exploratory exact tests. These analyses are univariable, unadjusted and hypothesis-generating and do not account for confounding, matching, convenience sampling or farm-level clustering.

DISCUSSION

Rearing is a behaviour in which the horse raises its forelimbs while standing on its hind limbs (McDonnell, 2003). Although it may occur in the normal behavioural repertoire, repeated or contextually inappropriate rearing can create important welfare and safety concerns. Previous reports

have emphasised that pain, inappropriate equipment, management conditions, training practices and rider-horse interactions should be considered when evaluating horses that exhibit this behaviour (Jonckheer-Sheehy et al., 2012; McGreevy et al., 2009; Romness et al., 2020).

Clinical evaluation should also include possible musculoskeletal discomfort, because back and sacroiliac region pain have been reported in horses with poor performance or ridden behavioural problems (Barstow and Dyson, 2015; Girodroux et al., 2009; Martin and Klide, 1999). In addition to individual clinical examination, the broader farm-level health and biosecurity context should be considered descriptively. Previous studies in Turkish horse populations have reported infectious disease risk factors and variability in biosecurity practices on horse properties (İnce and Sevik, 2022; İnce et al., 2024). However, these aspects were not analysed as determinants of rearing behaviour in the present study.

Behavior problems in horses are often thought to be due to the horse's bad attitude, which commonly results in them being punished. However, when these cases are carefully worked up, there may be an underlying physical problem, and pain may play an important role (Jonckheer-Sheehy et al. 2012). Furthermore, in academic studies, rearing behavior is generally defined as the horse's attempt to throw its rider off or its effort to escape from constraints that restrict its instinct to avoid an approaching danger. Similar findings were obtained in the conducted study.

The exploratory exact tests suggested differences in the selected sample by sex, intended use and recorded health status, whereas breed and age did not show evidence of distributional differences. These findings require substantial caution. The non-rearing group was smaller ($n = 21$) and was not individually matched to the rearing group, and the sample was obtained through convenience sampling. Consequently, the observed distributions may reflect selection mechanisms, confounding or differences in management context rather than independent relationships with rearing behaviour. In particular, recorded health problems were more frequent in the non-rearing group; this pattern must not be interpreted as evidence that health problems are protective against rearing. The breed, age, sex and intended-use distributions reported in this study should be interpreted primarily as characteristics of the selected sample. Although exploratory exact tests were performed, they do not establish susceptibility patterns, independent risk factors or causal relationships. Observations derived from owner interviews and field assessments may also be affected by reporting bias, recall bias and differences in management practices across farms. Future research should use prospectively defined case criteria, standardised behavioural assessment protocols, repeated direct observations, detailed clinical examinations and clearly defined observation periods. Larger multicentre studies should recruit adequately sized comparison groups, consider matching or design-based control of major confounders where appropriate, and use analytical models that account for farm-level clustering and relevant animal-level variables. A priori sample-size planning and adequately powered multivariable analyses will be necessary to evaluate potential factors associated with rearing behaviour.

This study has several limitations. The sample was restricted to participating farms in three provinces and was not selected to estimate prevalence in the wider horse population. The non-rearing group was small ($n = 21$) and unmatched, limiting statistical power and increasing vulnerability to confounding and selection bias. Behavioural classification was based on field observations and owner reports, which may be affected by reporting and recall bias. Several categories contained small numbers of horses, and standardised repeated behavioural scoring and detailed clinical examinations were not available for all horses. The exact tests were univariable and exploratory and did not account for farm-level clustering or other confounders. For these reasons, the findings cannot be used to identify independent risk factors or support causal inference.

CONCLUSION

Rearing behaviour should be evaluated on a case-by-case basis. When a horse repeatedly rears during riding or handling, potential pain and other health problems should first be excluded. Management conditions, training practices, equipment and rider-horse interactions should then be reviewed. The present exploratory study identified distributional differences in the selected sample for some categorical variables, but these findings do not establish independent factors associated with rearing behaviour. Future studies should use standardised behavioural assessment protocols, prospective sampling designs, adequately sized and appropriately selected comparison groups, detailed clinical examinations and powered analytical methods before conclusions about associated factors can be drawn.

Acknowledgements

The authors would like to thank the horse breeders for their support.

Ethics Approval

This study was evaluated by the Ethics Committee of Çukurova University, Ceyhan Faculty of Veterinary Medicine, and approved as ethically appropriate (Decision No: 2-4, Date: 13.02.2026).

Funding

There is not any funding in this study.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contributions

Research Design (CRediT 1) Yavuzkan Paksoy (%50) – Ömer Barış İnce (%25) – Nazan Koluman (%25)

Data Collection (CRediT 2) Yavuzkan Paksoy (%50) – Ömer Barış İnce (%25) – Nazan Koluman (%25)

Research - Data analysis - Validation (CRediT 3-4-6-11) Yavuzkan Paksoy (%25) – Ömer Barış İnce (%50) – Nazan Koluman (%25)

Writing the Article (CRediT 12-13) Yavuzkan Paksoy (%50) – Ömer Barış İnce (%25) – Nazan Koluman (%25)

Revision and Improvement of the Text (CRediT 14) Yavuzkan Paksoy (%50) – Ömer Barış İnce (%25) – Nazan Koluman (%25)

Sustainable Development Goals (SDG)

Sustainable Development Goals: 3 Good Health and Well-Being

REFERENCES

- Arabacı, H.M. (2018). Kitap İncelemesi Türklerde Atçılık Ve Binicilik Faruk Sümer. Dumlupınar Üniversitesi Sosyal Bilimler Dergisi, 57: 316-324.
- Barstow, A. & Dyson S.J. (2015). Clinical features and diagnosis of sacroiliac joint region pain in 296 horses: 2004–2014. Equine Vet. Educ. 27: 637–647.
- Gücüyener Hacan, Ö. & Akçapınar, H. (2013). Atlarda Davranış. Lalahan Hayvancılık Araştırma Enstitüsü Dergisi, 53(1): 47-57.
- Girodroux, M., Dyson, S. & Murray, R. (2009). Osteoarthritis of the thoracolumbar synovial intervertebral articulations: Clinical and radiographic features in 77 horses with poor performance and back pain. Equine Vet. J. 41: 130–138.
- Hacan, Ö., Koçak, S., Çelikel Oğlu, K., Bozkurt, Z., Erdoğan, M. & Tekerli, M. (2018). The Independent Spirit of Turkey: Wild Horse. Uluslararası Veteriner ve Hayvan Araştırmaları Dergisi, 1(1): 16-18.
- İnce, O.B. & Sevik, M. (2022). Equine arteritis virus seroprevalence and risk factors in horses in the inner Aegean and Central Anatolia regions of Turkey. Journal of the Hellenic Veterinary Medical Society, 73(2): 4159-4164.
- İnce, O., Paksoy, Y. & Sait, A. (2024). Risk assessment about effectiveness of biosecurity implementations on horse properties in Turkey. Journal of the Hellenic Veterinary Medical Society, 75(2): 7397–7406.
- Jonckheer-Sheehy, V.S.M., Delesalle, C.J., Van den Belt, A.J.M. & Van den Boom, R. (2012). Bad behavior or a physical problem? Rearing in a Dutch Warmblood mare. Journal of Veterinary Behavior, 7(6): 380-385.
- Martin, B.B. & Klide, A.M. (1999). Physical examination of horses with back pain. Vet. Clin. North Am. Equine Pr., 15: 61–70.
- McDonnell, S. (2003). A practical field guide to horse behavior: The equid ethogram Lexington, KY. Eclipse Pr Publishing.
- McGreevy, P.D., Oddie, C., Burton, F. & McLean, A. (2009). The horse–human dyad: Can we align horse training and handling activities with the equid social ethogram? Vet. J. 181:12–18.
- Paksoy, Y. & Ünal, N. (2010). Atlarda Yarış Performansını Etkileyen Faktörler. Lalahan Hayvancılık Araştırma Enstitüsü Dergisi, 50(2): 91-101.
- Paksoy, Y. & Gücüyener Hacan, Ö. (2023). Deprem Sonrası Bir Safkan İngiliz Atta Gözlenen Stereotipik Davranış: Kendi Etrafında Dönme. Kocatepe Veteriner Dergisi, 16(2): 248-251.
- Paksoy, Y. & Koluman N. (2025). At Yetiştiriciliğinde Fizyoterapi Uygulamalarının Önemi. Çukurova J. Agric. Food Sci., 40(1): 35-45.
- Paksoy, Y., Koluman N., Çelik Güney, M. & Arslan, D. (2025). Investigation of the Effects of Gender, Breed and Age Factors on Social Behavior, Withers Height and Body Weight in Dogs. Çukurova J. Agric. Food Sci., 40(2): 239-251.
- Paksoy, Y., Karataş Yeni, D., Ün, A.E. & Gökmen, M.C. (2026). Infectious Causes of Abortions and Stillbirths in Horse Breeding, Research and Practice in Veterinary and Animal Science

(REPVAS), 3(1), 57-66.

Romness, N., Fenner, K., McKenzie, J., et al. (2020). Associations between Owners' Reports of Unwanted Ridden Behaviour and In-Hand Behaviour in Horses. *Animals (Basel)*, 10(12): 2431.

Şehu, A. (1997). Spor Atlarının Beslenmesi. *Lalahan Hayvancılık Araştırma Enstitüsü Dergisi*, 37(1): 83-108.

Yalçın, E. (2009). Atlarda Stereotipik Davranışlar. *Uludağ Univ. J. Fac. Vet. Med*, 28(2): 49-53.

Waran, N. (2007). Preface, In: *The Welfare of Horse*, Ed: Natalie Waran, Published by Springer, pg: ix-x, Netherlands.