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# Research Trends Analysis of Veterinary Clinical Parasitology Worldwide

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## ABSTRACT

Veterinary clinical parasitology is a critical field that addresses the diagnosis, treatment, and prevention of parasitic infections in animals, impacting both animal and public health. This study comprehensively analyzes global research trends in veterinary clinical parasitology, utilizing data from Scopus mined in July 2024. From 1961 to mid-2024, 2,836 articles were identified, with an average annual publication rate of 45 documents. The United States emerged as the leading contributor with 644 publications, followed by Brazil (421), the United Kingdom (287), Italy (241), and Spain (235). Key topics driving research in this field include veterinary medicine, DNA extraction, RT-PCR, parasites and co-infections, indicating their ongoing relevance and importance. Data visualization through VOSviewer provided valuable insights into the evolving research landscape, highlighting significant patterns and collaborations within the field of veterinary clinical parasitology. Continued advancements in diagnostic techniques, treatment protocols and preventive measures are expected to enhance further the control and management of parasitic infections in animals.

**Key words:** Veterinary Clinical Parasitology; Research Trends; Scopus Data Analysis; VOSviewer; Parasitic Infections in Animals.

## INTRODUCTION

Veterinary clinical parasitology is a specialized field within veterinary science focused on the detection, diagnosis, treatment, and prevention of parasitic infections in animals. It plays a vital role in controlling parasitic disease transmission between animals and mitigating zoonotic risks to humans. Veterinary clinical parasitology is crucial for protecting both animal and public health, as it addresses the myriad challenges posed by parasitic infections in diverse animal populations. In addition, veterinary clinical parasitology is used to assess the prevalence of parasitic infections in different geographic regions. Factors such as climate and socioeconomic conditions can significantly influence infection rates, often leading to widespread parasitic infestations. For instance, the epidemiology of intestinal protozoan infections among schoolchildren in Asia is commonly associated with *Giardia duodenalis, Cryptosporidium spp., dan Entamoeba spp* (Abdoli et al. 2024). These infections are primarily acquired through consumption of water or food contaminated with parasitic protozoa. In addition, tropical regions tend to exhibit higher infection rates due to environmental factors such as warm temperatures and high humidity, which create optimal conditions for parasite transmission and distribution (Eslahi et al. 2023; Niaz et al. 2023; Abdoli et al. 2024).

Parasitic infections can be caused by ectoparasites such as ticks, mites, and flies, as well as endoparasites like protozoa and helminths (Jones and Garcia 2023). Parasites can be transmitted from infected animals to healthy animals or humans so that they can cause health problems and this condition is called zoonotic disease. The transmission of zoonotic diseases to humans can occur in various ways, such as from pets infected with parasites, blood transfusions from parasite-infected patients, consumption of undercooked and unclean food, consumption of water contaminated with parasites, and through insect bites as parasite-carrying vectors (Centers for Disease Control and Prevention 2024). Some examples of zoonotic diseases in

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humans include malaria, African trypanosomiasis, severe acute respiratory syndrome (SARS), COVID-19, Ebola virus disease, Middle East respiratory syndrome (MERS), influenza A (H1N1) 09, Nipah virus infection, anthrax and rabies (Debnath et al. 2021; Kotepui et al. 2021; Mehnaz et al. 2023; Cleveland Clinic 2024).

Diagnosing parasitic organisms can be done by morphological observation under a microscope to determine the type of parasite (Chessa et al. 2020; Cissokho et al. 2024). However, many parasites have different life cycles, so it is difficult to make observations to distinguish between species from morphological characteristics, which requires particular expertise and takes a relatively long time (Scheifler et al. 2019). The existence of technological developments such as next-generation sequencing (NGS) is the best choice for identifying communities of parasitic organisms (Chessa et al. 2020). Parasite identification is based on 18S ribosomal DNA (18S rDNA), so that identification can be specific to the species level in a fast time (Hino et al. 2016; Mthethwa et al. 2021). The 18S rDNA is used as a reference for identifying specific oligonucleotides in parasites, making it a valuable tool for detecting and analyzing parasite diversity (Harl et al. 2023). Veterinarians can also use the NGS application to determine the diversity of horse intestinal worms (Mitchell et al. 2019) and detect pathogenic protozoa in shellfish (DeMone et al. 2020). It can also be used to predict antimicrobial and antiviral resistance in certain species, so it plays a vital role in treating diseases caused by parasitic infections (Chiu and Miller 2019). In addition to using microscopy and NGS, diagnosis and identification of parasitic infections are also carried out by PCR detection, serological tests with enzyme-linked immunosorbent assay (ELISA) and western blots, and also microbial tests (Schwarz et al. 2017).

The diverse roles and contributions of veterinary clinical parasitology in managing parasitic infections highlight the critical need for further development of research in this field. Veterinary clinical parasitology has been a topic of interest from 1961 to 2024. Various studies and publications have been conducted and continue to evolve. Therefore, from year to year, a method is needed to analyze research trends related to veterinary clinical parasitology. Analyzing trends within literature is vital for informing the development of effective diagnostic, therapeutic, and preventive measures to mitigate these diseases' impact. Given the increasing complexity and evolving nature of parasitic diseases, thoroughly examining existing scientific research is essential to uncover emerging themes and identify leading contributors in the field. One method that can be used is bibliometric analysis (Van Eck and Waltman 2010). Through bibliometric analysis, quantitative analysis of publications, productivity of researchers and institutions, and widely researched topics can be found. Bibliometric analysis has been widely used to analyze research trends globally, such as in the fields of health (Sofyantoro et al. 2022a; Putri et al. 2023; Sofyantoro et al. 2023; Setiawan et al. 2024), natural products (Sofyantoro et al. 2022b) and biodiversity (Priyono et al. 2023). This study used bibliometric analysis of the Scopus database from 1961 to 2024. By utilizing data from the Scopus database, this study seeks to illuminate key trends and advancements in veterinary clinical parasitology, thereby identifying critical growth areas and suggesting potential avenues for future research exploration.

## MATERIALS AND METHODS

In this study, a bibliometric analysis was performed using the Scopus database to investigate research trends in Veterinary Clinical Parasitology. Data mining was carried out in July 2024 with the search query: TITLE-ABS-KEY (veterinary AND clinical AND parasitology). Bibliometric data such as titles, abstracts, keywords, authors, publication years, and citation counts were extracted. VOSviewer was then used to visualize and analyze co-authorship networks, keyword co-occurrences, and citation patterns, enabling the identification of emerging trends and key contributors in the field (Van Eck and Waltman 2010).

## RESULTS

### Publication trend on veterinary clinical parasitology

From 1961 to mid-2024, a total of 2,836 articles were published in the field of veterinary clinical parasitology, reflecting an average productivity rate of 45 documents per year. The majority of these publications were research articles (n=2,565), followed by reviews (n=201) and conference papers (n=20). Other document types included notes (n=18), book chapters (n=8), books (n=7), letters (n=6), short surveys (n=5), and editorials (n=3).

Most of the work appeared in journals (n=2,817), with a smaller number published as books (n=10) or within book series (n=8). The primary language of publication was English (n=2,769), with contributions in German (n=22), Portuguese (n=13), Chinese (n=10), and Spanish (n=9). Subject-wise, the majority of the articles focused on veterinary science (n=1,753), followed by immunology and microbiology (n=1,619), medicine (n=1,102) and agricultural and biological sciences (n=571). Other subjects included biochemistry, genetics, and molecular biology (n=99), multidisciplinary research (n=45) and various other topics. This diverse array of publications highlights the multifaceted nature of research in veterinary clinical parasitology, underscoring its significance across multiple scientific domains.

The global publication trend is shown in Fig. 1. The first publication was in 1961. Since 2004, the number of international publications has continued to increase significantly and in 2018, it reached the highest number with 303 documents.

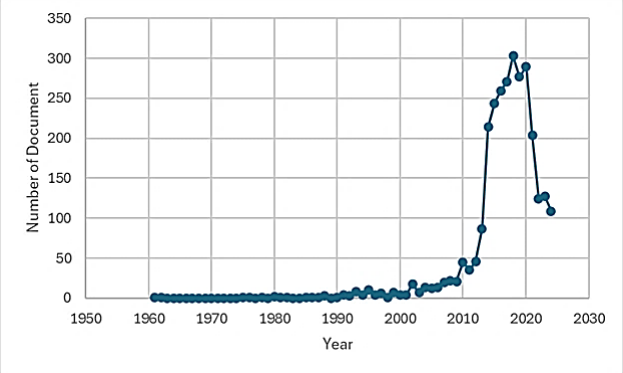



**Fig. 1:** Publication trend on veterinary clinical parasitology over six decades.

### Most cited articles on veterinary clinical parasitology

The top ten articles with the highest number of citations are shown in Table 1. The article entitled "Drug resistance in veterinary helminths" in the journal Trends in Parasitology published in 2004 became the article with the highest number of citation (n=671). Meanwhile, an article entitled "A review of canine babesiosis: The European perspective" published in Parasites and Vectors in 2016 has the lowest number of citations, namely 264 references.

### Top ten authors on veterinary clinical parasitology

Table 2 shows the author with the highest number of documents. Otranto, D. is the author with the highest number of documents, namely 51 documents, followed by Baneth, G. (n=41), Traversa, D. (n=36), and Di Cesare, A. (n=36). Meanwhile, the author with the lowest number of documents consists of Beugnet, F. with 21 documents.

Fig. 2 shows the number of author distribution clusters formed after being visualized with VOSviewer with a threshold of 7 documents. There are fourteen clusters with different colors. The clusters formed are represented by brown, green, light blue, yellow, pink, purple, red, dark blue, orange, etc (Fig. 2a). Meanwhile, Fig. 2b shows the author mapping based on the year of article publication. The color gradation from purple to yellow indicates old to new publication. The oldest publication year is 2016, while the most recent publication year of all authors is 2020.

**Table 1:** Most articles on veterinary clinical parasitology-related research

| SCR[a] | Article title | Author (s) | Journal | Vol (No):page/ article numbers | Year | Citation |
|---|---|---|---|---|---|---|
| 1 | Drug resistance in veterinary helminths | Wolstenholme et al. | Trends in Parasitology | 20(10):469–476 | 2004 | 671 |
| 2 | LeishVet guidelines for the practical management of canine leishmaniosis | Solano-Gallego et al. | Parasites and Vectors | 4(1):86 | 2011 | 550 |
| 3 | World Association for the Advancement of Veterinary Parasitology (W.A.A.V.P.) second edition of guidelines for evaluating the efficacy of anthelmintics in ruminants (bovine, ovine, caprine) | Wood et al. | Veterinary Parasitology | 58(3):181–213 | 1995 | 489 |
| 4 | The current status of zoonotic leishmaniases and approaches to disease control | Gramiccia & Gradoni | International Journal for Parasitology | 35(11-12):1169–1180 | 2005 | 381 |
| 5 | The FAMACHA© system for managing haemonchosis in sheep and goats by clinically identifying individual animals for treatment \| Utilisation du système FAMACHA© pour gérer l'hémonchose chez le mouton et la chèvre par l'identification clinique des animaux nécessitant un traitement | Van Wyk & Bath | Veterinary Research | 33(5):509–529 | 2002 | 372 |
| 6 | *Trypanosoma evansi* and surra: A review and perspectives on origin, history, distribution, taxonomy, morphology, hosts, and pathogenic effects | Desquesnes et al. | BioMed Research International | 2013:194176 | 2013 | 319 |
| 7 | The animal trypanosomiases and their chemotherapy: A review (Giordani et al. 2016) | Giordani et al. | Parasitology | 143(14):1862–1889 | 2016 | 280 |
| 8 | Control of visceral leishmaniasis in latin America - A systematic review | Romero & Boelaert | PLoS Neglected Tropical Diseases, | 4(1):e584 | 2010 | 272 |
| 9 | Canine and feline cardiopulmonary parasitic nematodes in Europe: Emerging and underestimated | Traversa et al. | Parasites and Vectors | 3(1):62 | 2010 | 269 |
| 10 | A review of canine babesiosis: The European perspective | Solano-Gallego et al. | Parasites and Vectors | 9(1):336 | 2016 | 264 |

[a]SCR: standard competition ranking.

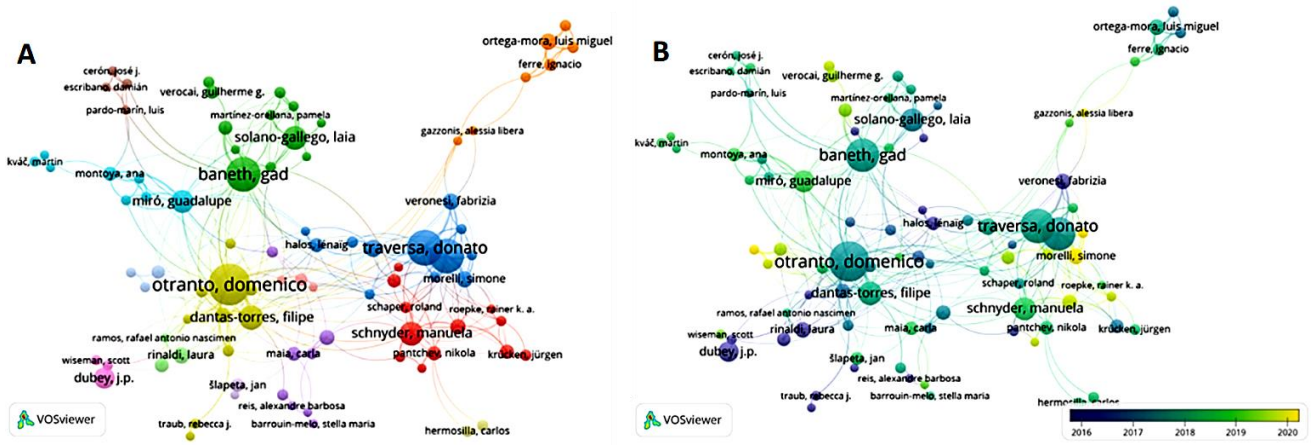



**Fig. 2:** Author distribution and collaboration in veterinary clinical parasitology research. (a) network visualization; (b) overlay visualization. The length of the connection indicates the level of linkage, with a minimum of 7 documents per author.

**Table 2:** The top ten authors on veterinary clinical parasitology research

| SCR[a] | Author | Document Number |
|---|---|---|
| 1 | Otranto, D. | 51 |
| 2 | Baneth, G. | 41 |
| 3 | Traversa, D. | 36 |
| 4 | Di Cesare, A. | 36 |
| 5 | Solano-Gallego, L. | 30 |
| 6 | Schnyder, M. | 28 |
| 7 | Dubey, J.P. | 27 |
| 8 | Dantas-Torres, F. | 24 |
| 9 | Ortega-Mora, L.M. | 23 |
| 10 | Beugnet, F. | 21 |

[a]SCR: standard competition ranking.

### The most contributed journal on veterinary clinical parasitology

Table 3 shows the top ten journals that publish the most about veterinary clinical parasitology research. The journal with the highest number of documents is Veterinary Parasitology, which has 356 documents, followed by Parasites and Vectors (n=280) and Parasitology Research (n=139). Meanwhile, Parasitology International is the journal with the lowest number of publications, at 46 documents.

**Table 3:** The most contributed journal on veterinary clinical parasitology research

| SCR[a] | Journal | Document Number |
|---|---|---|
| 1 | Veterinary Parasitology | 356 |
| 2 | Parasites and Vectors | 280 |
| 3 | Parasitology Research | 139 |
| 4 | Veterinary Parasitology Regional Studies and Reports | 94 |
| 5 | Revista Brasileira De Parasitologia Veterinaria | 71 |
| 6 | Plos Neglected Tropical Diseases | 65 |
| 7 | Journal of Veterinary Internal Medicine | 60 |
| 8 | BMC Veterinary Research | 58 |
| 9 | Veterinary Dermatology | 55 |
| 10 | Parasitology International | 46 |

[a]SCR: standard competition ranking.

### The institution with the top publication of veterinary clinical parasitology

Table 4 shows the top ten institutions with the highest number of publications on veterinary clinical parasitology research. The institution with the highest number of documents is Fundacao Oswaldo Cruz from Brazil, which has 98 documents. In the second position of the top ten institutions is Universidade Estadual Paulista "Júlio de Mesquita Filho" with 73 documents also from Brazil. In addition, there is also the Universidade de São Paulo from Brazil with 66 documents and is included in the top ten institutions. In the third position is the Universidad Complutense de Madrid institution from Spain, which has 68 papers. In contrast, the institution with the lowest number of publications is the Hebrew University of Jerusalem from Israel which has 52 documents.

### The top ten country on veterinary clinical parasitology research

The top ten countries are shown in Table 5. The United States is the country with the highest number of documents, at 644, and it collaborates with 70 countries. Brazil (n=421 documents) collaborated with 45 countries, and the United Kingdom (n=287) collaborated with 69 countries. The country with the lowest number of publications is China, which has 112 documents and collaborates with 22 countries.

Fig. 3 shows the number of country clusters formed after being visualized with VOSviewer with a threshold of 5 documents. There are eleven clusters with different colors. The clusters formed are represented by dark blue, red, yellow, green, orange, pink, light blue, etc (Fig. 3a). Meanwhile, Fig. 3b shows the country mapping based on the year of article publication. The color gradation from purple to yellow indicates old to new publication. The oldest publication year is 2015, while the most recent publication year of all countries is 2019.

### The most keyword on veterinary clinical parasitology research

Fig. 4 shows the keywords used as topics in clinical parasitology research. Fig. 4a shows the five keyword clusters formed after being visualized with VOSviewer with a threshold of 100 occurrences. The clusters formed are marked with red, green, blue, yellow, and purple colors. Fig. 4b shows the mapping of article publication year from the topic used. A purple-to-yellow color gradation shows old to new publications from 2016 to 2019. Fig. 4c shows the most used keywords. The lighter the color, the more frequently the topic is researched. Some popularly used topics include parasitology, veterinary medicine, isolation and purification, and feces analysis.

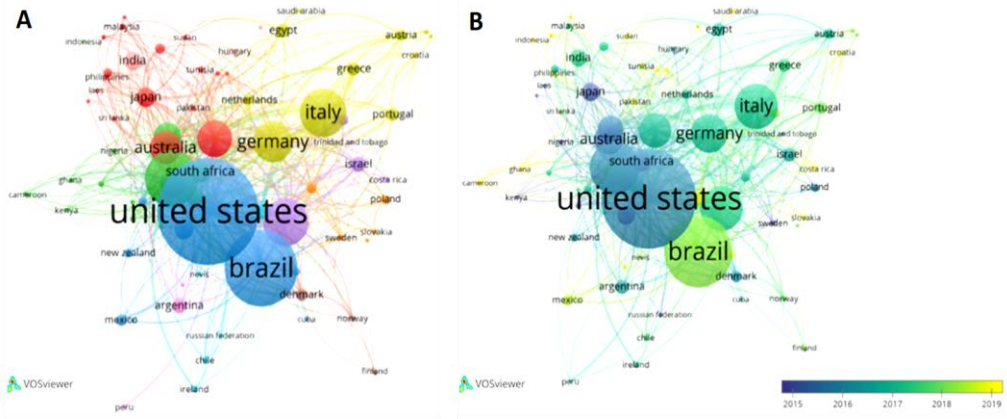
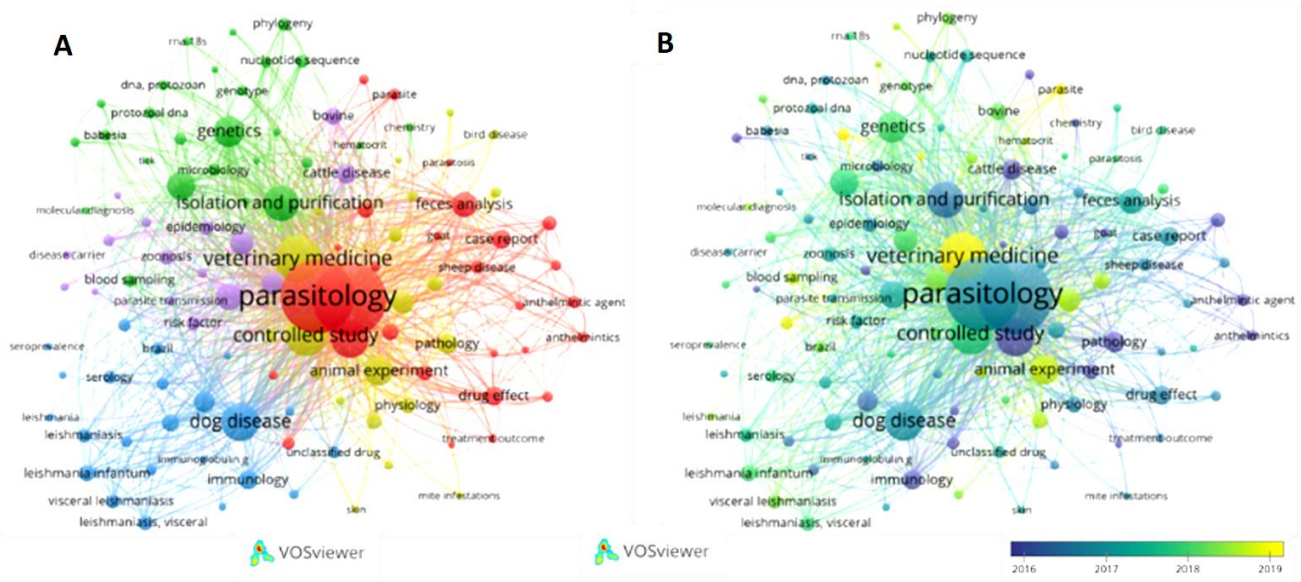



**Fig. 3:** Country mapping in veterinary clinical parasitology research. (a) network visualization; (b) overlay visualization. The length of the connection indicates the level of linkage, with a minimum of 5 documents per country.



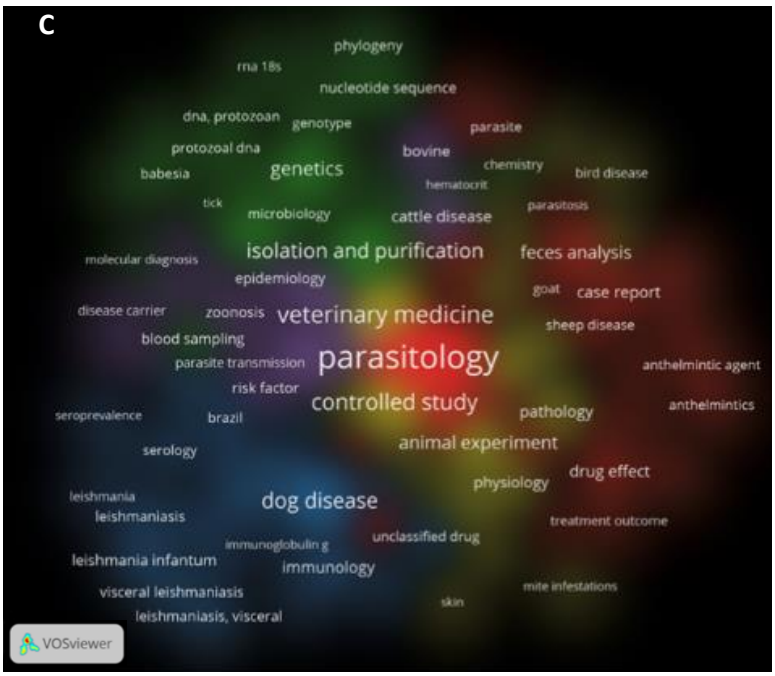




**Fig. 4:** Keyword mapping with VOSviewer in clinical parasitology research. (a) network visualization; (b) overlay visualization; (c) density cluster visualization. The distance between the connection and the 100 occurrences is shown by its length.

**Table 4:** The institution with the top publication of veterinary clinical parasitology

| SCR[a] | Institution | Country | Document number |
|---|---|---|---|
| 1 | Fundacao Oswaldo Cruz | Brazil | 98 |
| 2 | Universidade Estadual Paulista "Júlio de Mesquita Filho" | Brazil | 73 |
| 3 | Universidad Complutense de Madrid | Spain | 68 |
| 4 | Universidade de São Paulo | Brazil | 66 |
| 5 | University of California, Davis | United States | 63 |
| 6 | Universitat Autònoma de Barcelona | Spain | 62 |
| 7 | Universität Zürich | Switzerland | 57 |
| 8 | Università degli studi di Bari Aldo Moro | Italy | 56 |
| 9 | University of Pretoria | South Africa | 53 |
| 10 | Hebrew University of Jerusalem | Israel | 52 |

[a]SCR: standard competition ranking.

## DISCUSSION

Publication trends related to clinical parasitology research have experienced development for more than six decades, from 1961 to 2024. Bibliometric analysis shows a significant increase in the number of publications since 2004, and it reached the highest number of publications in 2018, with 303 documents. While the first document related to clinical parasitology research entitled "Clinical evaluation of surgical removal of adult heartworms (*Dirofilaria immitis*) from dogs" was successfully published in 1961 by the Journal of the American Veterinary Medical Association (Gourley 1961). Between 1961 and 2024, there were 2,836 documents published in

**Table 5:** The top ten countries in veterinary clinical parasitology research

| SCR[a] | Country | Document number | Collaborating country number[b] |
|---|---|---|---|
| 1 | United States | 644 | 70 |
| 2 | Brazil | 421 | 45 |
| 3 | United Kingdom | 287 | 69 |
| 4 | Italy | 241 | 46 |
| 5 | Spain | 235 | 47 |
| 6 | Germany | 197 | 48 |
| 7 | France | 171 | 48 |
| 8 | Australia | 149 | 40 |
| 9 | Switzerland | 124 | 43 |
| 10 | China | 112 | 22 |

[a]SCR: standard competition ranking; [b]Collaborating country with a minimum of 5 documents.

reputable journals. The average number of documents published was 45 documents per year and is predicted to continue to increase. Most of these publications consisted of research articles (n=2,565) and reviews (n=201). In addition, published documents were also sourced from journals (n=2,817), books (n=10) or within book series (n=8). Most documents are in English (n=2,769). Publications related to clinical parasitology have been conducted in various subject areas including veterinary science (n=1,753), immunology and microbiology (n=1,619), and also medicine (n=1,102). This shows that there has been an extraordinary development in clinical parasitology, which has been studied in various fields.

The trend in veterinary clinical parasitology research highlights the dynamic nature of the field, driven by technological advancements, emerging diseases, and global health challenges. The initial period of low publication rates likely reflected a time when the field was relatively mature but not a focal point of scientific inquiry. However, the rapid rise in research output from the mid-1990s onwards suggests a period of renewed interest and discovery, likely catalysed by external factors such as the emergence of new parasitic threats such as canine visceral leishmaniasis (CVL), technological innovations, and a greater emphasis on zoonotic diseases (Liu et al. 2018; Malaquias et al. 2007). This pattern of growth is not unique to veterinary parasitology but is observed in many scientific fields where technological innovations and global health concerns drive research activity. The post-2020 decline may be a temporary phase, influenced by the extraordinary circumstances of the COVID-19 pandemic, or it might indicate a broader shift in the research landscape and lead to a shift in research priorities (Mobasheri 2020). Moving forward, the field of veterinary clinical parasitology might see new waves of interest as researchers address emerging challenges such as climate change-induced shifts in parasite distribution, the impact of urbanization on wildlife and domestic animals, and the role of parasites in ecosystems (Fox et al. 2015; Rose et al. 2014).

Various authors, countries, and institutions have actively conducted research and publications for more than six decades. The article entitled "Drug resistance in veterinary helminths" in the journal Trends in Parasitology published in 2004 became the article with the highest number of references, namely 671 references (Wolstenholme et al. 2004). This shows that the article is popularly used as a reference in research and preparing publication manuscripts related to clinical parasitology. The author with the highest number of publication documents is Otranto, D., with 51 documents, followed by Baneth, G., Traversa, D., and Di Cesare, A. with 41 documents and 36 documents, respectively. Most of the top ten authors who contributed to clinical parasitology research published in the 2016-2020 timeframe. Many of these studies have been published in various reputable journals. Veterinary Parasitology is the journal that publishes the most clinical parasitology research publications with 356 documents. One of the documents published by Veterinary Parasitology entitled "World Association for the Advancement of Veterinary Parasitology (W.A.A.V.P.) second edition of guidelines for evaluating the efficacy of anthelmintics in ruminants (bovine, ovine, caprine)" managed to become one of the top ten highest number of citations (Wood et al. 1995). This was followed by Parasites and Vectors, which had 280 documents, and Parasitology Research, which had 139 documents. Parasites and Vectors successfully published many articles that were included in the top ten highest number of citations, including articles entitled "LeishVet guidelines for the practical management of canine leishmaniosis (Solano-Gallego et al. 2011), “Canine and feline cardiopulmonary parasitic nematodes in Europe: Emerging and underestimated” (Traversa et al. 2010), and article entitled "A review of canine babesiosis: The European perspective"(Solano-Gallego et al. 2016).

Publications were made by institutions all over the world. Institutions that contribute to the top ten institutions with the highest number of documents include Fundacao Oswaldo Cruz (n=98 documents), Universidade Estadual Paulista "Júlio de Mesquita Filho" (n=73 documents) from Brazil, and Universidad Complutense de Madrid from Spain with 68 documents. In addition, there is also the Universidade de São Paulo institution from Brazil, which also managed to become one of the top ten institutions with the highest publication documents. The high productivity of Brazilian institutions made this country the second top ten country on veterinary clinical parasitology research with 421 documents, the United States in the first position with 644 documents, and the United Kingdom in the third position with 287 documents. The countries with the highest number of collaborations are the United States, which collaborated with 70 countries; the United Kingdom with 69 countries; and Germany and France with 48 countries. Most of the publications published by the top ten countries were published from 2015 to 2019. Popular topics widely used and researched for more than six decades include parasitology, veterinary medicine, isolation and purification, and feces analysis.

Veterinary clinical parasitology is one part of veterinary medicine. It focuses on diagnosing, treating, and preventing various animal-borne parasitic infections. Diagnosing parasites infecting animals can be done by microscopy, molecular detection, serology, and blood tests. Generally, parasite analysis in animals uses fecal samples. The animal feces can be used as a sample in parasite identification because it contains bacteria and parasite eggs that can infect soil and humans. In addition, animal feces can also provide an overview of gastrointestinal infections and malabsorption syndrome (Kasırga 2019). Soil provides optimal conditions for parasite development so parasites

can easily transfer from animal feces to the environment. Animal feces diagnosis can be made using several methods, such as double centrifugation with Sheather's sugar flotation solution (DCFS) and mini-parasite (Apacor) flotation kit (MPF). The DCFS method is the most effective method to identify *Platynosomum fastosum* parasite infection and several helminth eggs such as *Ancylostoma tubaeforme*, *Trichuris* species, and *Toxocara cati* in cat feces (Eisenbraun et al. 2020). Fecal egg counts in animals can also be done by microscopy examination or using PCR with specific primers to identify the parasite species infecting the animals based on parasite DNA (Pauling et al. 2016). Molecular diagnosis of parasitic organisms can be performed using the PCR technique. This method begins with isolating and purifying DNA samples for PCR analysis. Paulos et al. (2016) reported that PCR can be used to analyze the parasitic protozoa *Cryptosporidium* spp., *Giardia duodenalis*, and *Entamoeba* spp. (Paulos et al. 2016).

Parasitic infections can be treated with the use of antibacterials, antifungals, antiprotozoal, and anthelmintic. Azithromycin, clarithromycin, erythromycin, and fidaxomicin are antibacterials that can inhibit parasitic infections. Meanwhile, antifungals include amphotericin B, posaconazole, itraconazole, and caspofungin (Abdulaziz et al. 2022). In addition, parasitic antiprotozoal can be treated with the use of nitroimidazole, clefamide, amphotericin-B, oxytetracycline, trimethoprim-sulfametoxazole, paramomycin, and nitrazoxadine (Trasia 2021). Anthelmintics have two mechanisms in inhibiting the growth of helminth parasites, namely the mechanism of vermicides by killing worms and vermifuges helping to eliminate worms. Some drugs used as anthelmintic are praziquantel, miclosamide, metrifonate, oxamniquine, and albendazole (Campbell and Soman-Faulkner 2024). Treatment of parasite infections can be prevented by early detection and routine health checks. Therefore, veterinary clinical medicine is one of the exciting topics that will be researched and developed in the future.

**Future perspective**

Coupled with continuous research and technological developments, the future of veterinary clinical parasitology is bright. From the overall exploration of research trends globally from 1961 to mid-2024, some focus areas and future directions might be drawn in light of it. Next-generation sequencing and the newer generation of CRISPR-based diagnostics help maximize the sensitivity and specificity to rapidly and more precisely diagnose infection. Novel antiparasitic drugs and therapies, like drug-targeted delivery systems and immunotherapies, will maximize treatment outcomes focused on mechanisms of drug resistance. Through progress with genomics and proteomics, preventive measures and vaccines shall contribute to long-term control and eradication. The present study identifies vital patterns and associations that support the need for strengthening international partnerships and collaborative data-sharing efforts as a means to improve understanding and control of these parasitic diseases. Future research must consider climate change's impact on parasite-host dynamics and a One Health approach to the zoonotic potential. Integrated into data analysis and disease modeling, artificial intelligence and machine learning will help work out outbreak patterns and optimize treatment regimens. Veterinarians should be better equipped with education and training against upcoming challenges. Attention to these areas will allow the further evolution of the field of veterinary clinical parasitology toward continued contribution to improved animal health, public health safety, and ecosystem well-being.

**Conclusion**

Research and publications related to veterinary clinical parasitology research have increased for more than six decades, from 1961 to 2024. Two thousand eight hundred thirty-six documents are published in various reputable journals, averaging 45 documents per year. Veterinary clinical parasitology research includes diagnosing, treating, and preventing animal parasitic infections. This shows that veterinary clinical parasitology is an interesting topic that continues to be researched by various well-known institutions and published in reputable journals. In addition, this study also provides an overview of the potential development of veterinary clinical parasitology in the future.

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**Author's contribution:** IR: Conceptualization, Methodology, Software, Writing - Original Draft, Visualization. UNWA: Methodology, Writing - Original Draft, Visualization. FS: Writing – Review & Editing, Validation. ARS: Writing – Review & Editing, Validation. EM: Writing – Review & Editing, Validation. WAP: Supervision, Validation, Investigation, Writing – Review & Editing, Project administration.

**REFERENCES**

Abdoli A, Olfatifar M, Eslahi AV, Moghadamizad Z, Nowak O, Pirestani M, Karimipour-saryazdi A, Badri M and Karanis P, 2024. Prevalence of intestinal protozoan parasites among Asian schoolchildren: A systematic review and meta-analysis. Infection 52(6): 2097-2133. https://doi.org/10.1007/s15010-024-02339-1

Abdulaziz L, Elhadi E, Abdallah EA, Alnoor FA and Yousef BA, 2022. Antiviral activity of approved antibacterial, antifungal, antiprotozoal and anthelmintic drugs: Chances for drug repurposing for antiviral drug discovery. Journal of Experimental Pharmacology 14: 97–115. https://doi.org/10.2147/JEP.S346006

Campbell S and Soman-Faulkner K, 2024. Antiparasitic Drugs. In StatPearls. StatPearls Publishing, Florida.

Centers for Disease Control and Prevention, 2024. What Causes Parasitic Diseases. Parasites. https://www.cdc.gov/parasites/causes/index.html. Accessed 12 July 2024.

Chessa D, Murgia M, Sias E, Deligios M, Mazzarello V, Fiamma M, Rovina D, Carenti G, Ganau G, Pintore E, Fiori M, Kay GL, Ponzeletti A, Cappuccinelli P, Kelvin DJ, Wain J and

Rubino S, 2020. Metagenomics and microscope revealed *T. trichiura* and other intestinal parasites in a cesspit of an Italian nineteenth century aristocratic palace. Scientific Reports 10(12656): 1-10. https://doi.org/10.1038/s41598-020-69497-8

Chiu CY and Miller SA, 2019. Clinical metagenomics. Nature Reviews Genetics 20: 341–355. https://doi.org/10.1038/s41576-019-0113-7

Cissokho B, Sambe Babacar S, Diome T, Ndiaye MR and Sembene M, 2024. In vitro nematocidal effects of aqueous extracts of leaves and bark of *Khaya senegalensis* and *Azadirachta indica* on the mortality of adults of *Haemonchus contortus*, Cobb, 1899 (Rhabditida, Trichostrongylidae). Agrobiological Records 18: 105-112. https://doi.org/10.47278/journal.abr/2024.042

Cleveland Clinic, 2024. Zoonotic Diseases. Cleveland Clinic. https://my.clevelandclinic.org/health/diseases/zoonotic-diseases. Accessed 12 July 2024

Debnath F, Chakraborty D, Deb A, Saha M and Dutta S, 2021. Increased human-animal interface & emerging zoonotic diseases: An enigma requiring multi-sectoral efforts to address. Indian Journal of Medical Research 153(5-6): 577-584. https://doi.org/10.4103/ijmr.IJMR_2971_20

DeMone C, Hwang MH, Feng Z, McClure JT, Greenwood SJ, Fung R, Kim M, Weese JS and Shapiro K, 2020. Application of next generation sequencing for detection of protozoan pathogens in shellfish. Food and Waterborne Parasitology 21: e00096. https://doi.org/10.1016/j.fawpar.2020.e00096

Desquesnes M, Holzmuller P, Lai DH, Dargantes A, Lun ZR and Jittaplapong S, 2013. *Trypanosoma evansi* and surra: A review and perspectives on origin, history, distribution, taxonomy, morphology, hosts, and pathogenic effects. Biomed Research International 2013(1): 1-22. http://doi.org/10.1155/2013/194176

Eisenbraun H, Alluwie A, Connolly S, Nair R, Verocai GG and Ketzis JK, 2020. Comparison of fecal analysis methods for the detection of *Platynosomum fastosum* in naturally infected cats. Journal of Feline Medicine and Surgery 22(4): 395–398. https://doi.org/10.1177/1098612X19848173

Eslahi AV, Olfatifar M, Zaki L, Saryazdi AK, Barikbin F, Maleki A, Abdoli A, Badri M and Karanis P, 2023. Global prevalence of intestinal protozoan parasites among food handlers: A systematic review and meta-analysis. Food Control 145: 109466. https://doi.org/10.1016/j.foodcont.2022.109466

Fox NJ, Marion G, Davidson RS, White PCL and Hutchings MR, 2015. Climate-driven tippingpoints could lead to sudden, high-intensity parasite outbreaks. Royal Society Open Science 2(5): 1-14. https://doi.org/10.1098/rsos.140296

Giordani F, Morrison LJ, Rowan TG, De Koning HP and Barrett MP, 2016. The animal trypanosomiases and their chemotherapy: A review. Parasitology 143(14): 1862-1889. https://doi.org/10.1017/S0031182016001268

Gourley IM, 1961. Clinical evaluation of surgical removal of adult heartworms (*Dirofilaria immitis*) from dogs. Journal of the American Veterinary Medical Association 139: 684–690.

Gramiccia M and Gradoni L, 2005. The current status of zoonotic leishmaniases and approaches to disease control. International Journal for Parasitology 35(11-12): 1169-1180. https://doi.org/10.1016/j.ijpara.2005.07.001

Harl J, Himmel T, Ilgūnas M, Valkiūnas G and Weissenböck H, 2023. The 18S rRNA genes of *Haemoproteus* (Haemosporida, Apicomplexa) parasites from European songbirds with remarks on improved parasite diagnostics. Malaria Journal 22(232): 1-18. https://doi.org/10.1186/s12936-023-04661-9

Hino A, Maruyama H and Kikuchi T, 2016. A novel method to assess the biodiversity of parasites using 18S rDNA Illumina sequencing; parasitome analysis method. Parasitology International 65(5): 572–575. https://doi.org/10.1016/j.parint.2016.01.009

Jones KR and Garcia GW, 2023. Teaching of veterinary parasitology to university students in Trinidad, West Indies; Are our local wildlife species neglected? Brazilian Journal of Biology 83: e248493. https://doi.org/10.1590/1519-6984.248493

Kasırga E, 2019. The importance of stool tests in diagnosis and follow-up of gastrointestinal disorders in children. Turkish Archives of Pediatrics 54(3): 141-148. https://doi.org/10.14744/TurkPediatriArs.2018.00483

Kotepui KU, Masangkay FR, De Jesus Milanez G and Kotepui M, 2021. Prevalence and outcomes of malaria as co-infection among patients with human *African trypanosomiasis*: A systematic review and meta-analysis. Scientific Reports 11: 1-10. https://doi.org/10.1038/s41598-021-03295-8

Liu GH, Zhang LX, Zou FC, Yuan ZG, Zhao GH, Hu M, Suo X and Zhu XQ, 2018. Veterinary parasitology teaching in China in the 21st century-challenges, opportunities and perspective. Veterinary Parasitology 252: 70-73. https://doi.org/10.1016/j.vetpar.2018.01.037

Malaquias LCT, Romualdo RDC, Do Anjos Jr JB, Giunchetti RC, Correa-Oliveira R and Reis AB, 2007. Serological screening confirms the re-emergence of canine leishmaniosis in urban and rural areas in Governador Valadares, Vale do Rio Doce, Minas Gerais, Brazil. Parasitology Research 100(2): 233-239. https://doi.org/10.1007/s00436-006-0259-z

Mehnaz S, Abbas RZ, Kanchev K, Rafique MN, Aslam MA, Bilal M, Ather AS, Zahid A and Batool T, 2023. Natural control perspectives of *Dermanyssus gallinae* in poultry. International Journal of Agriculture and Biosciences 12(3): 136-142. https://doi.org/10.47278/journal.ijab/2023.056

Mitchell CJ, O'Sullivan CM, Pinloche E, Wilkinson T, Morphew RM and Mcewan NR, 2019. Using next-generation sequencing to determine diversity of horse intestinal worms: Identifying the equine 'nemabiome.' Journal of Equine Science 30(1): 1–5. https://doi.org/10.1294/jes.30.1

Mthethwa NP, Amoah ID, Reddy P, Bux F and Kumari S, 2021. A review on application of next-generation sequencing methods for profiling of protozoan parasites in water: Current methodologies, challenges, and perspectives. Journal of Microbiological Methods 187(106269): 1-13. https://doi.org/10.1016/j.mimet.2021.106269

Mobasheri A, 2020. COVID-19, Companion Animals, comparative medicine, and one health. Frontiers in Veterinary Science 7(522): 1-5. https://doi.org/10.3389/fvets.2020.00522

Niaz M, Sindhu ZUD, Munir F, Ejaz S, Aslam B, Abbas RZ, Khan MK and Imran M, 2023. Parasite control practices used by horse owners in Punjab, Pakistan. International Journal of Agriculture and Biosciences 12(4): 257-261. https://doi.org/10.47278/journal.ijab/2023.073

Pauling CD, Oller AR and Jackson V, 2016. Fecal parasite identification by microscopy and PCR in scimitar-horned oryx, *Oryx dammah*, managed at two sites. International Journal for Parasitology: Parasites and Wildlife 5(3): 312–320. https://doi.org/10.1016/j.ijppaw.2016.11.001

Paulos S, Mateo M, De Lucio A, Hernández-de Mingo M, Bailo B, Saugar JM, Cardona GA, Fuentes I, Mateo M and Carmena D, 2016. Evaluation of five commercial methods for the extraction and purification of DNA from human faecal samples for downstream molecular detection of the enteric protozoan parasites *Cryptosporidium* spp., *Giardia duodenalis*, and *Entamoeba* spp. Journal of Microbiological Methods 127: 68–73. https://doi.org/10.1016/j.mimet.2016.05.020

Priyono DS, Sofyantoro F, Putri WA, Septriani NI, Rabbani A and Arisuryanti T, 2023. A bibliometric analysis of Indonesia biodiversity identification through DNA barcoding research from 2004-2021. Natural Life Sciences

Communications 22(1): e2023006. https://doi.org/10.12982/NLSC.2023.006

Putri WA, Setiawan J, Sofyantoro F, Priyono DS, Septriani NI, Mafiroh WU, Yano Y and Wasityastuti W, 2023. Global research trends in non-alcoholic fatty liver disease. Bratislava Medical Journal 124(8): 590–598. https://doi.org/10.4149/BLL_2023_092

Romero GAS and Boelaert M, 2010. Control of *Visceral leishmaniasis* in Latin America-A systematic review. PloS Neglected Tropical Disease 4(1): e584. https://doi.org/10.1371/journal.pntd.0000584

Rose H, Hoar B, Kutz SJ and Morgan ER, 2014. Exploiting parallels between livestock and wildlife: Predicting the impact of climate change on gastrointestinal nematodes in ruminants. International Journal for Parasitology: Parasites and Wildlife 3(2): 209-219. https://doi.org/10.1016/j.ijppaw.2014.01.001

Scheifler M, Ruiz-Rodríguez M, Sanchez-Brosseau S, Magnanou E, Suzuki MT, West N, Duperron S and Desdevises Y, 2019. Characterization of ecto- and endoparasite communities of wild Mediterranean teleosts by a metabarcoding approach. PLOS ONE 14(9): e0221475. https://doi.org/10.1371/journal.pone.0221475

Schwarz NG, Loderstaedt U, Hahn A, Hinz R, Zautner AE, Eibach D, Fischer M, Hagen RM and Frickmann H, 2017. Microbiological laboratory diagnostics of neglected zoonotic diseases (NZDs). Acta Tropica 165: 40–65. https://doi.org/10.1016/j.actatropica.2015.09.003

Setiawan J, Rizal DM, Sofyantoro F, Priyono DS, Septriani NI, Mafiroh WU, Kotani T, Matozaki T and Putri WA, 2024. Bibliometric analysis of organoids in regenerative medicine-related research worldwide over two decades (2002–2022). Regenerative Medicine 19(3): 119–133. https://doi.org/10.2217/rme-2023-0176

Sofyantoro F, Frediansyah A, Priyono DS, Putri WA, Septriani NI, Wijayanti N, Ramadaningrum WA, Turkistani SA, Garout M, Aljeldah M, Al Shammari BR, Alwashmi ASS, Alfaraj AH, Alawfi A, Alshengeti A, Aljohani MH, Aldossary S and Rabaan AA, 2023. Growth in chikungunya virus-related research in ASEAN and South Asian countries from 1967 to 2022 following disease emergence: A bibliometric and graphical analysis. Globalization and Health 19(9): 1-14. https://doi.org/10.1186/s12992-023-00906-z

Sofyantoro F, Kusuma HI, Vento S, Rademaker M and Frediansyah A, 2022a. Global research profile on monkeypox-related literature (1962–2022): A bibliometric analysis. Narra Journal 2(3): e96. https://doi.org/10.52225/narra.v2i3.96

Sofyantoro F, Yudha DS, Lischer K, Nuringtyas TR, Putri WA, Kusuma WA, Purwestri YA and Swasono RT, 2022b. Bibliometric Analysis of Literature in Snake Venom-Related Research Worldwide (1933–2022). Animals 12(16): 2058. https://doi.org/10.3390/ani12162058

Solano-Gallego L, Miró G, Koutinas A, Cardoso L, Pennisi MG, Ferrer L, Bourdeau P, Oliva G and Baneth G, 2011. LeishVet guidelines for the practical management of canine leishmaniosis. Parasite. Vectors 4: 86. https://doi.org/10.1186/1756-3305-4-86

Solano-Gallego L, Sainz Á, Roura X, Estrada-Peña A and Miró G, 2016. A review of canine babesiosis: The European perspective. Parasite and Vectors 9: 336. https://doi.org/10.1186/s13071-016-1596-0

Trasia RF, 2021. Drug of choice in the treatment of protozoa infection in Indonesia. Journal of Pharmaceutical and Sciences 4(2): 101–104. https://doi.org/10.36490/journal-jps.com.v4i2.65

Traversa D, Di Cesare A and Conboy G, 2010. Canine and feline cardiopulmonary parasitic nematodes in Europe: Emerging and underestimated. Parasite and Vectors 3: 62. https://doi.org/10.1186/1756-3305-3-62

Van Eck NJ and Waltman L, 2010. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics 84(2): 523–538. https://doi.org/10.1007/s11192-009-0146-3

Van Wyk JA and Bath GF, 2002. The FAMACHA system for managing haemonchosis in sheep and goats by clinically identifying individual animals for treatment. Veterinary Research 33(5): 509-529. https://doi.org/10.1051/vetres:2002036

Wolstenholme AJ, Fairweather I, Prichard R, Von Samson-Himmelstjerna G and Sangster NC, 2004. Drug resistance in veterinary helminths. Trends Parasitology 20(10): 469–476. https://doi.org/10.1016/j.pt.2004.07.010

Wood IB, Amaral NK, Bairden K, Duncan JL, Kassai T, Malone JB, Pankavich JA, Reinecke RK, Slocombe O, Taylor SM and Vercruysse J, 1995. World Association for the Advancement of Veterinary Parasitology (W.A.A.V.P.) second edition of guidelines for evaluating the efficacy of anthelmintics in ruminants (bovine, ovine, caprine). Veterinary Parasitology 58(3): 181–213. https://doi.org/10.1016/0304-4017(95)00806-2