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The Impact of Parasites on Farm Animal Productivity: A Review

Mohamed Omar Abdalla Salem [1 *], Rabiaa Abdulrahem Saleh Alalwany [2], Asma Saleh Omer Bassoss [3], Soad Moftah Awnallah Alsshabo [4]

[1] Department of Biology, Faculty of Education, Bani Waleed University, Bani Waleed, Libya.

[2] Department of Zoology, Faculty of Science, University of Kufra, Kufra, Libya

[3,4] Department of Zoology, Faculty of Science, Bani Waleed University, Bani Waleed, Libya.

[*]*Correspondence*: MohamedSalem@bwu.edu.ly

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Abstract:

Parasitic infestations represent a significant and often underestimated constraint on global livestock productivity, with profound implications for food security, economic sustainability, and animal welfare. While traditionally the domain of veterinary science, the environmental drivers of parasite transmission, particularly soil and water interactions, are critical determinants of infection pressure within agricultural systems. This review synthesizes current knowledge on the major parasitic groups (helminths, protozoa, ectoparasites) affecting key farm animal species (ruminants, swine, poultry). We detail the multifaceted mechanisms through which parasites reduce productivity, including impaired nutrient utilization, reduced growth rates, diminished milk and egg yields, reproductive inefficiencies, morbidity, and mortality. Critically, the role of environmental factors – soil type, moisture, temperature, pasture management, and water quality – in mediating parasite life cycles and transmission is emphasized. The economic burden encompasses direct production losses and costs associated with control measures, including the growing challenge of anthelmintic resistance. This review underscores the necessity of integrated parasite management (IPM) strategies that combine targeted anthelmintic use, environmental modification, genetic selection, and nutritional interventions. Collaboration between parasitologists, veterinarians, animal scientists, and environmental specialists (particularly soil and water scientists) is paramount for developing sustainable solutions that mitigate parasite impacts while preserving environmental health and productivity.

Keywords: Livestock Parasites, Helminths; Protozoa, Ectoparasites, Animal Productivity, Growth Performance, Milk Yield.

تأثير الطفيليات على إنتاجية حيوانات المزرعة: مراجعة

محمد عمر عبدالله سالم [1*]، ربيعة عبدالرحمن صالح العلواني [2]، أسماء صالح عمر بصوص [3]، سعاد مفتاح عون الله الشبو [4]

[1]قسم الاحياء، كلية التربية، جامعة بني وليد، بني وليد، ليبيا

[2]قسم علم الحيوان، كلية العلوم، جامعة الكفرة، الكفرة، ليبيا

[4,3]قسم علم الحيوان، كلية العلوم، جامعة بني وليد، بني وليد، ليبيا

الملخص

تُمثل الإصابات الطفيلية عائقًا كبيرًا، وغالبًا ما يُقلل من أهميته، على إنتاجية الثروة الحيوانية العالمية، مع تداعيات عميقة على الأمن الغذائي والاستدامة الاقتصادية ورفاهية الحيوان. ورغم أن الطب البيطري هو المجال التقليدي للعوامل البيئية المسببة لانتقال الطفيليات، وخاصةً تفاعلات التربة والمياه، تُعدّ عوامل حاسمة في ضغط العدوى داخل النظم الزراعية. تُلخص هذه المراجعة المعارف الحالية حول المجموعات الطفيلية الرئيسية (الديدان الطفيلية، والطفيليات الأولية، والطفيليات الخارجية) التي تؤثر على أنواع رئيسية من حيوانات المزرعة (المجترات، والخنازير، والدواجن). وتُفصّل الآليات متعددة الجوانب التي تُقلل من خلالها الطفيليات من الإنتاجية، بما في ذلك ضعف الاستفادة من العناصر الغذائية، وانخفاض معدلات النمو، وانخفاض إنتاج الحليب والبيض، وقصور التكاثر، ومعدلات الاعتلال، والنفوق. كما يُشدد البحث على دور العوامل البيئية - نوع التربة، والرطوبة، ودرجة الحرارة، وإدارة المراعي، وجودة المياه - في تحديد دورات حياة الطفيليات وانتقالها.

يشمل العبء الاقتصادي خسائر الإنتاج المباشرة والتكاليف المرتبطة بتدابير المكافحة، بما في ذلك التحدي المتزايد المتمثل في مقاومة طاردات الديدان. تُؤكد هذه المراجعة على ضرورة اتباع استراتيجيات الإدارة المتكاملة للطفيليات (IPM) التي تجمع بين الاستخدام المُستهدف لطاردات الديدان، والتعديل البيئي، والانتقاء الجيني، والتدخلات الغذائية. يُعد التعاون بين علماء الطفيليات، والأطباء البيطريين، وعلماء الحيوان، والمتخصصين البيئيين (وخاصةً علماء التربة والمياه) أمرًا بالغ الأهمية لتطوير حلول مستدامة تُخفف من آثار الطفيليات مع الحفاظ على الصحة البيئية والإنتاجية.

الكلمات المفتاحية: طفيليات الماشية؛ الديدان الطفيلية، الأوليات؛ الطفيليات الخارجية، إنتاجية الحيوان، أداء النمو، إنتاج الحليب.

Introduction

Livestock production is a cornerstone of global agriculture, providing essential protein, fiber, and draft power. Maximizing the productivity and efficiency of farm animals is crucial for meeting the demands of a growing human population. However, numerous health challenges impede optimal production, among which parasitic diseases are arguably the most pervasive and economically significant [1]. Parasites, encompassing a diverse array of organisms including helminths (nematodes, trematodes, cestodes), protozoa (e.g., Eimeria, Cryptosporidium, Babesia), and ectoparasites (ticks, mites, lice, flies), exert a continuous drain on animal resources.

The impact of parasitism extends far beyond overt clinical disease. Subclinical infections, often chronic and insidious, are widespread and result in substantial, quantifiable losses in growth, feed conversion efficiency, milk production, wool yield, egg production, and reproductive performance [2], [3], [4], [5], [6]. These losses occur through multiple pathways: competition for nutrients, damage to digestive and absorptive tissues, immune activation costs, blood loss, organ damage, and increased susceptibility to secondary infections.

Understanding the epidemiology and control of livestock parasites necessitates an appreciation of their environmental context. Soil and water are fundamental components of the transmission cycle for many critical parasites. Infective larval stages of gastrointestinal nematodes (e.g., Haemonchus, Ostertagia, Trichostrongylus) develop on pasture herbage from eggs deposited in feces; their survival, development, and migration are profoundly influenced by soil moisture, temperature, texture, and organic matter content [7], [8]. Water bodies serve as habitats for intermediate hosts (snails) essential for the life cycles of trematodes like *Fasciola hepatica* (liver fluke). Runoff and soil erosion can transport parasite eggs and oocysts (e.g., Cryptosporidium, Giardia) into water sources, posing risks within and beyond the farm boundary [9], [10].

This review aims to:

1) Outline the major parasitic groups affecting key farm animal species; 2) Quantify and describe the mechanisms of their impact on various productivity parameters; 3) Highlight the critical role of environmental factors, particularly soil and water, in parasite transmission dynamics; 4) Discuss the economic consequences; and 5) Evaluate current and emerging control strategies, emphasizing the need for integrated, environmentally informed approaches.

Major Parasitic Groups and Their Impacts on Productivity

1. Gastrointestinal Nematodes (GIN):

Primarily affect ruminants (cattle, sheep, goats). Cause reduced feed intake, impaired digestion and nutrient absorption (especially protein), increased gut permeability, and chronic blood loss (haemonchosis). Consequences include significantly reduced weight gain (up to 30-50% in severe subclinical infections), lower milk yield (5-15% or more), decreased wool growth, poor body condition, reduced reproductive efficiency (delayed puberty, lower conception rates), and increased susceptibility to other diseases [11], [12], [13]. Subclinical ostertagiosis in cattle is a classic example of hidden production losses.

Larval development on pasture is highly dependent on soil moisture and temperature. Microclimate within the fecal pat and at the soil/herbage interface is crucial. Heavy rainfall can disperse larvae; drought can arrest development but larvae survive in feces.

2. Liver Fluke (Fasciola hepatica and F. gigantica):

Major parasite of ruminants. Causes acute/subacute disease (liver damage, hemorrhage) and chronic disease (bile duct fibrosis, anemia, hypoproteinemia). Leads to reduced weight gain, lower milk yield, decreased fertility, liver condemnation at slaughter, and significant mortality in outbreaks [14], [15], [16], [17].

Absolutely dependent on specific aquatic or amphibious snail intermediate hosts (Galba truncatula and others). Transmission requires suitable snail habitats – poorly drained pastures, muddy areas, ditches, slow-moving streams [18], [19]. Soil moisture and water pH are critical for snail survival.

3. Lungworms (e.g., Dictyocaulus viviparus in cattle):

Cause parasitic bronchitis ("husk"). Impairs lung function, leading to reduced feed intake, weight loss, reduced milk yield, coughing, and potentially fatal respiratory distress [20], [21].

Infective larvae develop on pasture from eggs/larvae shed in feces. Survival and migration depend heavily on moisture and temperature. Heavy dew or rain facilitates larval movement onto herbage.

4. Coccidia (e.g., Eimeria spp.):

Affect all major livestock, especially young animals. Damage intestinal epithelium, causing diarrhea (sometimes hemorrhagic), malabsorption, dehydration, reduced weight gain, impaired feed efficiency, and mortality [22], [23], [24]. Significant in poultry (reduced weight gain, egg production drops) and ruminants.

Oocysts are highly resistant in the environment. Soil and litter provide a reservoir. Moisture facilitates sporulation. Runoff can contaminate water sources. Overcrowding and wet bedding exacerbate transmission.

5. Ectoparasites:

Ticks: Cause blood loss, anemia, skin damage, tick worry (reduced grazing time), transmission of serious blood-borne diseases (e.g., babesiosis, anaplasmosis, theileriosis), injection site damage, and potential paralysis. Directly reduce weight gain and milk yield [25], [26], [27], [28], [29].

Mites (Mange): Cause intense irritation, scratching, hair/wool loss, skin thickening, and secondary infections. Severely impacts feed intake, weight gain, milk yield, wool/hide quality, and overall welfare [25].

Lice: Cause irritation, anemia (sucking lice), hair/wool loss, and reduced feed efficiency and weight gain [25], [29].

Flies (Biting/Non-biting): Cause irritation, blood loss (biting flies), "fly worry" (reduced grazing/resting time, bunching), transmission of pathogens, and myiasis (screw-worm, blowflies). Significant impact on weight gain and milk production [30], [31], [32].

Many ectoparasites have environmental stages (eggs, larvae, pupae) that develop in soil, litter, or vegetation. Soil moisture and temperature critically influence development rates and survival. Ticks often quest in vegetation influenced by soil moisture levels. Flies often breed in moist organic matter (manure, wet soil, decaying vegetation).

Economic Consequences

The economic burden of parasites is immense and multifaceted:

- Direct Production Losses: Reduced weight gain, lower milk/egg/wool output, decreased fertility, increased mortality, condemnation of organs/meat.
- Control Costs: Expenses for anthelmintics, acaricides, insecticides, veterinary services, labor for application, diagnostic testing.
- Infrastructure/Management Costs: Fencing for pasture management, drainage improvements, housing modifications.
- Anthelmintic Resistance (AR): The development and spread of resistance to major drug classes (especially in GIN of small ruminants, increasingly in cattle) significantly escalates control costs and complexity, threatening sustainable production.
- Global estimates of annual losses run into tens of billions of US dollars, with significant variation between regions, farming systems, and parasite species.

The Role of Soil and Water in Transmission Dynamics

The interface between the host, the parasite, and the environment (especially soil and water) is pivotal:

- Survival & Development: Soil moisture is arguably the most critical factor for free-living stages of most helminths and ectoparasite eggs/larvae. Optimal moisture enables development and movement; desiccation is lethal. Soil temperature regulates development speed. Soil texture and organic matter influence microclimate and physical protection[33], [34].
- Pasture Contamination & Infectivity: Fecal deposition patterns and environmental conditions determine the spatial and temporal distribution of infective stages on pasture. Rainfall events can trigger mass emergence and dispersal of larvae. Soil erosion transports parasite propagules into watercourses [35].
- Intermediate Host Ecology: The distribution and abundance of snail intermediate hosts for flukes are entirely dependent on suitable aquatic or semi-aquatic habitats, defined by water availability, pH, vegetation, and soil type/saturation [16], [36], [37].
- Water as a Vector & Risk: Contaminated water sources (ponds, streams, troughs) can directly transmit parasites like Cryptosporidium and Giardia, and harbor intermediate hosts for flukes. Poor water quality can also stress animals, increasing susceptibility.

Control Strategies and Integrated Parasite Management (IPM)

Reliance solely on chemical control (anthelmintics, acaricides) is unsustainable due to resistance, residues, and cost. IPM combines multiple tactics:

- Strategic/Targeted Selective Treatment (TST): Using diagnostics (Fecal Egg Counts - FEC, coproantigen tests, performance markers) to treat only animals that need it, or at times of highest risk, reducing selection pressure for resistance [24].
- Pasture/Rotation Management: Rotational grazing, mixed/alternate species grazing, pasture spelling, haymaking, avoiding high-risk areas (wet pastures for fluke/snails). Requires understanding of larval/pupal ecology on pasture and in soil [18], [38].
- Genetic Selection: Breeding animals for parasite resistance/resilience (e.g., based on FEC or FAMACHA scores) is a powerful long-term tool [16].
- Nutritional Management: Ensuring optimal nutrition (especially protein and minerals) enhances immune function [5], [39], [40], [41], [42], [43], [44].
- Biological Control: Investigating the use of nematophagous fungi (*Duddingtonia flagrans*) to reduce larval populations in feces.
- Environmental Modification: Drainage of wet areas to reduce fluke snail habitats and moisture for nematode larvae/ectoparasite stages.
- Improving manure management to break parasite life cycles.
- Protecting water sources from contamination.
- Vaccination: Limited availability (e.g., Dictyocaulus in cattle, Eimeria in poultry), but active research area.

Conclusion

Parasites remain a major impediment to efficient and sustainable farm animal production globally. Their impact is not merely clinical but predominantly manifests as substantial, often hidden, losses in growth, yield, reproduction, and feed efficiency. Critically, the transmission and persistence of the most significant parasites are inextricably linked to environmental factors, with soil conditions (moisture, temperature, texture) and water availability/quality playing fundamental roles in determining infection pressure.

The escalating problem of anthelmintic resistance underscores the failure of reliance on chemical control alone. Sustainable management requires a paradigm shift towards Integrated Parasite Management (IPM), which necessitates a deep understanding of parasite life cycles within the context of the farm environment.

Recommendations:

1) Prioritize Diagnostics: Implement regular monitoring (FEC, coproantigen, serology, performance tracking) to inform targeted treatments and assess program efficacy.
2) Adopt Targeted Selective Treatment (TST): Treat only animals showing signs of production impact or high parasite burden based on diagnostics, preserving refugia and slowing resistance.
3) Implement Strategic Pasture Management: Utilize rotational grazing, pasture spelling, mixed species grazing, and avoid grazing high-risk areas during peak transmission periods. Manage forage height and stocking density.
4) Invest in Genetic Improvement: Incorporate parasite resistance/resilience traits into breeding programs.
5) Optimize Nutrition: Ensure balanced diets, particularly adequate protein and key minerals (e.g., copper, selenium), to support immune function.
6) Modify the Environment: Improve drainage in fluke-prone areas. Manage manure effectively to reduce contamination. Fence off water bodies to prevent access by livestock where possible. Ensure clean water provision.
7) Promote Collaboration: Foster interdisciplinary collaboration between farmers, veterinarians, animal scientists, soil scientists, hydrologists, and agro-ecologists to develop holistic, site-specific IPM strategies that consider soil health, water resources, and farm ecosystem dynamics.
8) Support Research: Increase research into:

- Refining diagnostic tools for field use.
- Understanding soil-parasite interactions (survival, development, migration under varying conditions).
- Developing novel control methods (vaccines, biological control agents, bioactive forages).
- Quantifying the economic impact of subclinical parasitism and the cost-benefit of IPM strategies.
- Mitigating the impact of climate change on parasite epidemiology.

9) Education and Knowledge Transfer: Provide accessible training and resources for farmers and advisors on parasite biology, IPM principles, and resistance management.

By integrating sound animal health management with a profound understanding of the environmental drivers of parasitism, particularly the crucial roles of soil and water, the livestock sector can significantly reduce the burden of parasites, enhance productivity and sustainability, and ensure long-term food security.

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