Gut Health in Veterinary Medicine

Subjects: Agriculture, Dairy & Animal Science

Contributor: Elena Colombino

In recent decades, the term “gut health” has become increasingly popular and frequently used in the scientific literature regarding human and veterinary medicine. A consensus on the definition of “gut health” has not yet been reached as the intestine is a complex organ with digestive, immunological, neurological and endocrine functions. Gut health is generally defined as the absence, prevention or avoidance of intestinal disease so that the animal is able to perform its physiological functions in order to withstand exogenous and endogenous stressors. However, a broader definition of gut health should cover multiple positive aspects of the gastrointestinal tract including effective digestion and absorption of feed, the proper structure of gastrointestinal barrier, the absence of gastrointestinal illness, normal and stable intestinal microbiota, effective immune status, and proper control of the enteric nervous system.

gut health veterinary medicine bibliometric analysis

1. Gut health: an overview

Gut health relies on the maintenance of a delicate balance between the host, the intestinal environment and the dietary compounds [1]. Recently, it has also been shown that there is an extensive communication between the brain and the microbiota via the brain-gut-microbiome axis. Through this bidirectional communication, signals from the brain can influence the motor/sensory/secretory functions of the gut, and visceral messages from the gut can influence brain function [2]. On the one hand, in food producing animals, gut health can be considered a synonymous of animal health, strictly linked to animals’ growth performances. In fact, if gut health is compromised, digestion and nutrient absorption are affected with a detrimental effect on feed conversion ratio leading to economic loss and a greater susceptibility to disease [1]. On the other, in companion animals a healthy gut is crucial for their well-being and changes in gut microbiota have already been related to a multitude of disorders such as inflammatory bowel disease (IBD) but also cardiovascular disease and allergies [3][4]. Moreover, fecal microbiome transplant has been studied as a treatment option for multiple gastrointestinal diseases, such as IBD [5].

Gut health can be significantly affected by factors such as animal’s management, feed quality and environment . To date, a large number of studies have proved that diet is the most influential factor on gut health [1][6][7]. In fact, innovative feed ingredients, probiotics and prebiotics could positively modulate gut microbiota [8], gut barrier function [6][7] and mucin composition [9] with a significant reduction in disease incidence both in pets and food-producing animals. Moreover, stress has been proven to have a negative effect on gut health impairing especially gut microbiota and causing dysbiosis, which is a disruption of the microbiota composition accompanying intestinal inflammation [10].

To date, modulation of gut health could play a key role in reducing the need of antimicrobials and in protecting animals from diseases, which is particularly relevant considering the ban on the use of antimicrobial growth promoters imposed by the European Union in 2006 and the reassessment of their use in the USA [11]. Finding alternatives to antibiotics for mantaining gut health as well as systemic health in animals is even more important in a concept of One Health in order to help preserving the effectiveness of antimicrobials that are important for human medicine by reducing their use in animals [12].

Despite the high number of published articles and reviews on the topic, the evolution of the research in gut health still remains largely unknown.

2. Current trend and future perspective in veterinary gut health

We evaluate through a bibliometric analysis the current publication trends and dynamics in veterinary gut health research. The analysis showed an increased number of publications in veterinary gut health in the last decade. The majority of documents were published in China and USA between 2011 and 2020, being primarily research articles. The yielded documents mainly focused on poultry, pigs and aquaculture and the most discussed research topics were linked to nutrition and dietetics.

The evaluation of publications time span in the last 21 years (2000–2020) showed that gut health is an emerging research topic. In fact, the annual number of publications has been constantly increased, reaching its high in 2020 and reflecting an overall steady improvement. It could be hypothesized that the growing interest in gut health followed the European Union ban on antimicrobial growth promoters (AGP) in animal feed in 2006 as gut health-related problems became an important issue in intensive animal farming [13]. Thus, many researchers at the beginning of the XXI century focused their research work in finding valuable alternatives to antibiotics that could positively modulate gut health, boosting this new research topic [14].

The majority of publications were research articles (n = 1427, 84.1%) mainly focused on “Nutrition & Dietetics” (n = 1405, 82.8%), “Agriculture” (n = 1362, 80.3%), “Gastroenterology & Hepatology” (n = 1118, 65.9%), “Veterinary Sciences” (n = 876, 51.7%), and “Biochemistry & Molecular Biology” (n = 801, 47.2%). This could be explained by the fact that gut health has been demonstrated to be mainly influenced by diet . Thus, the veterinary gut health research focused on testing the effect of different feed ingredients or additives on multiple gut parameters. Moreover, in recent years, “Microbiology” gained importance among the research areas studied in veterinary gut health (n = 120, 7.1%). Current research has recognized that the composition of gut microbiota or the microbiome is one of the key factors in maintaining gut health as it is involved in nutrient absorption, feed digestibility, energy harvest and therefore animals’ productivity [15]. In addition, the development of next-generation sequencing techniques and biomolecular techniques helped in having a deeper insight into the microbiological aspects of gut health [16]. The presence of different research areas also demonstrated that a multidisciplinary approach is needed for an exhaustive evaluation of veterinary gut health [13].

Regarding animal species, most of the studies focused on pigs (34.8%), poultry (33.9%) and aquaculture (15.0%). This is probably due to the fact that poultry and pigs are ones of the most ubiquitous livestock species worldwide with almost 19.60 billion chickens and 0.98 billion pigs in the world [17]. Moreover, poultry, and pigs were the main livestock sectors that used AGP and they were more affected by the ban imposed by the EU in 2006, requiring valuable alternatives [13][18]. Aquaculture represents the main source of valuable animal protein worldwide and it attracted increasing attention due to the decline of capture fisheries, becoming the fastest growing food production animal worldwide [19]. Moreover, a greater interest in improving these rearing systems and optimizing animal productive performances through the modulation of gut health has grown in response to increasing demand for animal-based protein for human consumption [20]. However, a lack of knowledge in ruminants (cows, sheep and goats), horses, rabbits, cats and dogs was detected. A possible explanation for this gap is the difficulty in conducting research in these animals, particularly ruminants and pets. On the one hand, ruminants have a longer production cycle and require bigger spaces for their rearing compared to other species, making them difficult to use in research [21]. On the other, companion animals are more difficult to enroll for clinical trials or research works and non-invasive procedures must be preferred, representing a potential limitation for researchers.

This trend is also confirmed by the appearance of rainbow trout, pigs and chickens among the 35 most cited keywords plus. Moreover, keyword's network highlighted three main areas of interest: (i) one related to animal nutrition and zootechnical parameters; (ii) one related to immunology, gene expression and oxidative stress and (iii) one related to microbiology and infectious disease. This revealed that the main research lines are aimed to test different dietary feed ingredients, improve animals' productivity, prevent gastrointestinal diseases and drive microbiota composition [22]. However, it can be pointed out that some innovative concepts such as gut–brain axis and fecal transplants were not detected among the most frequent keywords, suggesting that they probably need to be developed in the next future. In fact, the gut–brain axis seems to influence the host neural function and behavior, particularly those relevant to stress-related disorders. Thus, regulating the gut microbiome could help improving animal welfare [23]. Moreover, fecal transplants has been explored as a treatment for IBD in dogs but whether it is an effective and safe option for canine IBD still remains unknown [24].

The top-3 most prolific journals were *Journal of Animal Science* (8.9%), *Poultry Science* (8.6%) and *Animals* (4.0%). These are all English language journals and they are all included in the first quartile for *Agriculture, Dairy and Animal Science* according to 2019 JCR. *Journal of Animal Science* and *Animals* encompass a broad range of research topics in animal production and fundamental aspects of genetics, nutrition, physiology, preparation and utilization of animal products. On the contrary, *Poultry Science* is the highest-ranked (by Impact Factor) journal dedicated to publishing poultry research and it also account for three of the top-20 cited documents on veterinary gut health (Baurhoo et al., 2007; Yegani et al., 2008 and Awad et al., 2009). Interestingly, the fourth most prolific journal is Aquaculture which is one of the top-ranked journals in "Marine and freshwater biology" according to JCR. This is in accordance with the three top-studied species and with the keyword's analysis.

Geographical distribution of publication on veterinary gut health is mainly located in China (24.7% of total publication) and USA (17.2%). Accordingly, the three most productive institutions were also from China (China

Agricultural University and Sichuan Agricultural University) and USA (North Carolina State University). This pattern is far from being restricted to veterinary gut health. In fact, USA and China were the most productive countries in Agricultural and Biological Science according to Scimago Journal and Country Rank (https://www.scimagojr.com/countryrank.php, Access date: 19 February 2021) and they were also the first countries for poultry, pig and fish production systems [20].

Considering the author's metrics, the majority of the top-20 most prolific authors started to publish in 2010 and the m-index showed that they have had a high scientific production in a relatively short period of time. Thus, this corroborates that gut health is a relatively novel research topic and it is in accordance with the greater growth of research on veterinary gut health observed from 2011. Moreover, the great numbers of citations achieved by the top-20 most prolific authors and by the 20-most cited papers in this short period of time reflects the growing interest of the scientific community on the topic.

This study has several limitations. Firstly, the search was conducted solely in WoS, thus articles and journals not listed in this database have not been included in the results with a possible underestimation of them. Nevertheless, WoS is a long and well-established database characterized by a wide range of scientific journals [25]. Secondly, in the search equation some of the species were grouped (e.g., poultry and fish) and this can lead to possible inclusion bias. However, an exhaustive search including the main species was conducted. Thirdly, WoS and Bibliometrix were used for data extraction and transformation. These procedures can provoke misleading results or missing data. Therefore, the bibliographic information was independently revised by EC and DP-B. Despite these limitations, to the author's knowledge this is the first bibliometric analysis addressing veterinary gut health. Furthermore, this study offers insightful data on the research areas, animal species, main contributors and publication's performances on veterinary gut health. Finally, this study can help to detect potential gaps of knowledge and address future research on gut health.

3. Conclusions

This study showed that gut health is a relevant research area in veterinary medicine with a constant increment in publication from 2010 to present. The current research mainly focuses on pigs, poultry and aquaculture with three main lines of research: nutrition, immunology and microbiology. An important gap of knowledge was also detected regarding research on other species, mainly ruminants, horses, rabbits, cats and dogs. In conclusion, future research could focus on the evaluation of gut health in the abovementioned less investigated species in order to explore its main component (animal nutrition, zootechnical parameters, immunology, gene expression, oxidative stress and microbiota) that have been already explored in pigs, poultry and aquaculture. Regardless of the species, future investigations should deepen in novel areas such as the evaluation of gut–brain axis and its function or the potential of fecal microbiota transplants as a treatment for gastrointestinal diseases.

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