

# A Bibliometric Approach for Evaluation of the Use of the MARS Model in Animal Breeding

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**Abstract**— This study aims to examine the use of the Multiple Adaptive Regression Splines (MARS) method in the field of animal husbandry from a bibliometric perspective. MARS is increasingly gaining attention in areas such as animal breeding, genetic selection, feed efficiency and live weight estimation due to its capacity to model complex and nonlinear relationships. Within the scope of bibliometric analysis, studies published in the relevant literature will be scanned through international databases such as Web of Science and Scopus, and publication trends, most cited articles, influential authors, collaborative networks and subject headings will be examined in detail. In addition, scientific collaborations and changes in the research agenda will be revealed using analysis tools such as R software, VOSviewer and CiteSpace. This analysis will provide an important reference source to determine current trends and future research opportunities in the use of the MARS method in animal breeding.

**Keywords**— MARS, R Software, Bibliometric, Animal Science, Livestock Production

## I. INTRODUCTION

In recent years, data science and artificial intelligence-based methods in agriculture and animal husbandry have been rapidly increasing [1]. Various data analytics methods are being applied to increase efficiency in animal production, improve genetic selection, and manage breeding processes more effectively [2]. Traditional statistical models may be insufficient to fully represent the complex and nonlinear relationships between many biological variables [3]. This has encouraged the more widespread use of nonlinear regression techniques and machine learning algorithms in animal husbandry. The Multivariate Adaptive Regression Splines (MARS) method has become an important analysis tool in many areas such as animal breeding, growth estimation, feed consumption modeling, and the effects of environmental factors on animal performance, thanks to its ability to create flexible structures in data sets [4] [5].

The MARS method provides superiority in capturing complex patterns in data compared to classical regression models and uses regional spline functions to explain nonlinear relationships with automatic variable selection [6]. This feature facilitates the process of determining relationships between variables in large data sets and allows for a better understanding of biological processes in animal husbandry. In addition, the MARS model contributes to developing decision support systems in animal husbandry science by modeling the interactions between genetic data, environmental factors and

management strategies.

However, there is no comprehensive bibliometric study that systematically addresses the use of the MARS model in the field of animal breeding and examines its place in the scientific literature. Bibliometrics is a powerful method that analyzes the publication trends, citation networks, the most contributing researchers and collaborative relationships of scientific publications on a specific topic [7]. Such an analysis is of great importance in terms of guiding future research by revealing how the MARS model is positioned in animal breeding and in which areas it is used the most.

The main purpose of this study is to perform a bibliometric analysis on the use of the MARS method in animal breeding science and to examine the spread, impact and development process of this model in the literature. In this direction, international scientific databases such as Web of Science and Scopus will be scanned and parameters such as publication numbers, distribution by years, most cited studies, influential authors and collaboration networks will be analyzed. The data obtained will help determine the trend of the MARS method in scientific research, in which countries and institutions it is intensively studied, and in which subfields it is used the most.

This study will make an important contribution to understanding the current research trends of the MARS model in animal husbandry and to identifying potential research gaps for future studies. It will also guide scientists on how machine learning-based prediction models can be optimized in animal husbandry. In conclusion, this bibliometric analysis study is an important initiative to evaluate the place of the MARS method in the field of animal breeding from an academic perspective and to provide a universal perspective on the literature.

## II. MATERIAL AND METHODS

In this study, bibliometric analysis of scientific publications on the use of the Multiple Adaptive Regression Splines (MARS) method in animal husbandry science was performed. The Web of Science (WoS) database was used for literature review. During the data collection process, a systematic search was conducted with certain keywords to determine how the MARS method was used in research in the field of animal husbandry. The search query was created as follows: "Multivariate Adaptive Regression Splines" AND "animal science" OR "livestock production"

As a result of this query, 63199 scientific publications were identified. The obtained data were analyzed in detail in terms of publication distribution by year, most cited studies, influential researchers, collaboration networks and subject headings. R software was used for bibliometric analysis in the study. By means of these software, citation networks, author collaborations, country-based publication distribution and keyword clusters were visualized and scientific productivity and research trends were revealed.

In order to increase the reliability and validity of the results obtained, the analyzed data were classified using certain filters. In terms of publication type, articles, reviews and conference papers were taken into consideration; editorials, book chapters and short notes were excluded. In addition, only studies published in English were evaluated.

The bibliometric analysis carried out in line with this method was conducted to determine the current position of the MARS method in animal husbandry science, its distribution according to research areas and potential directions for future research. The statistical analysis was carried out by using R software with the bibliometrix package [8].

### III. RESULTS

In this study, the results of the bibliometric analysis conducted to determine the place of the Multiple Adaptive Regression Splines (MARS) method in scientific publications in the field of animal husbandry are presented. As a result of the systematic search conducted in the Web of Science database, 63199 scientific studies were identified. The obtained publications were examined in detail in terms of distribution by year, citation analyses, most contributing authors, countries and institutions, collaboration networks and keyword clusters.

The analysis findings show that the MARS method is increasingly used in animal breeding research, that significant publication increases have been experienced in certain periods and that there are active collaborations in this field on a global scale. Citation analyses revealed that some studies have a high impact on the field and that certain authors focus on the MARS model. In addition, through bibliometric mappings, it was determined in which subfields of animal husbandry the MARS model is studied more and what the most frequently used conceptual frameworks are.

In the following sections, the results obtained will be detailed and publication trends, most cited articles, leading researchers, international collaboration networks and distribution of subject headings will be presented comprehensively.

The data presented in Table 1 comprehensively demonstrate the place of the Multiple Adaptive Regression Splines (MARS) algorithm in scientific publications in animal husbandry science. The bibliometric analysis covering the time period between 1970 and 2025 shows that a total of 63,199 scientific documents are associated with the MARS algorithm. The annual average growth rate of 10.26% reveals that the use of this method in animal husbandry science is increasing steadily. In addition, the average number of citations per document is 21.24, indicating that the studies on the MARS algorithm have a significant impact on the literature.

TABLE I:  
MAIN INFORMATION ABOUT THE MARS ALGORITHM IN ANIMAL SCIENCE STUDIES

Description	Results
<b>MAIN INFORMATION ABOUT DATA</b>	
Timespan	1970:2025
Sources (Journals, Books, etc)	6121
Documents	63199
Annual Growth Rate %	10.26
Document Average Age	10.8
Average citations per document	21.24
<b>DOCUMENT CONTENTS</b>	
Keywords Plus (ID)	53811
Author's Keywords (DE)	87784
<b>AUTHORS</b>	
Authors	154010
Authors of single-authored docs	3959
<b>AUTHORS COLLABORATION</b>	
Single-authored docs	5145
Co-Authors per Doc	5.33
International co-authorships %	30.3
<b>DOCUMENT TYPES</b>	
article	50016
article; book chapter	812
article; data paper	39
article; early access	248
article; early access; retracted publication	1
article; proceedings paper	1987
article; retracted publication	21
biographical-item	39
book	7
book review	20
correction	100
correction, addition	13
correction; early access	1
editorial material	534
editorial material; book chapter	20
editorial material; early access	1
item about an individual	12
letter	45
meeting	2
meeting abstract	446
news item	23
note	191
proceedings paper	3205
proceedings paper; book chapter	1
reprint	6
retraction	1
review	5294
review; book chapter	55
review; early access	51
review; retracted publication	8

When evaluated in terms of document content, it is seen that the keywords determined by the author (Author's Keywords) are 87,784 and the extended keywords (Keywords Plus) are 53,811. This situation shows that the MARS model is addressed within a wide range of topics in different research contexts. It has been determined that 154,010 different authors have contributed to this field and it is seen that an average of 5.33 authors have contributed to each document. The fact that international collaborations are 30.3% shows that the MARS algorithm has a place in multidisciplinary studies on a global scale. When the types of publications are examined, it is seen that the largest share belongs to original research studies with

50,016 articles. In addition, 5,294 compilation studies, 3,205 conference proceedings and 812 book chapters support scientific productivity in this field. Another noteworthy finding is the presence of 1,987 congress papers and 534 editorial materials, which shows that the MARS algorithm is not only discussed in academic articles but also through scientific discussions and conference presentations. In addition, the presence of a total of 5,145 single-authored articles reveals that individual research also has an important place. In conclusion, bibliometric data show that the MARS algorithm is increasingly important in animal husbandry science and that research in this field has spread to a wide academic domain. Studies on the MARS model attract attention with their high citation rates and international collaborations, which prove that the method is scientifically accepted and used in various disciplines.

Figure 1 shows the annual scientific production trend on the Multiple Adaptive Regression Splines (MARS) algorithm in animal husbandry science. The increase in the number of scientific publications over the years is clearly observed in the graph. Especially since the early 2000s, the use of the MARS algorithm has gained momentum and has shown a significant increase trend after 2010. This situation reveals that the MARS model is increasingly accepted in the field of animal husbandry and is widely used in scientific studies.

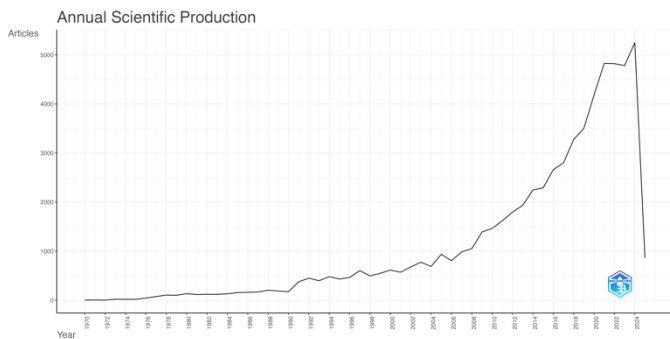


Fig. 1. Annual scientific production for MARS algorithm in animal science

The significant increase in the number of publications in recent years can be explained by the increased adoption of machine learning and data mining techniques in animal husbandry science. The ability of the MARS model to model nonlinear relationships, which can be adapted to topics such as genetic selection, growth performance predictions and feed efficiency, may have increased the popularity of this method in research. Overall, this trend suggests that the MARS algorithm is increasingly being adopted in animal science and will continue to be an important research tool in the future.

Figure 2 shows the institutions that have made the most scientific contributions to the Multiple Adaptive Regression Splines (MARS) algorithm in animal husbandry science. The graph shows the academic and research institutions that have produced the most publications in the relevant research field. This analysis reveals which institutions have researched and published the MARS method the most in animal husbandry.

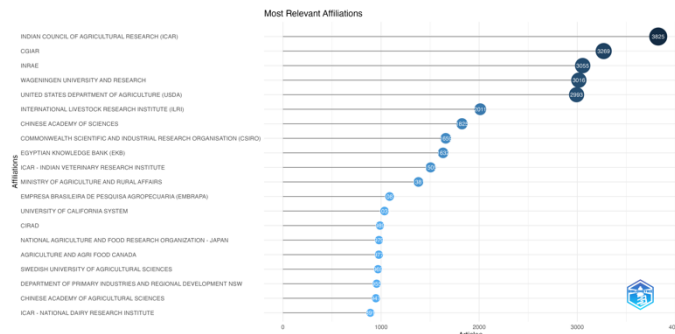


Fig. 2. Most relevant affiliations for MARS algorithm in animal science

First of all, when the graph is examined, it is seen that certain universities and research centers stand out. The institutions in the first places are conducting intensive research on the integration of machine learning-based analyses into animal husbandry practices. The institutions in the top ranks in terms of the number of publications are generally centers that provide access to large-scale research projects and large data sets. However, these results show that the MARS model is concentrated in certain academic centers, but is increasingly being adopted by a wider research community. In addition, international collaborations and contributions from academic institutions on different continents reveal that the MARS method is gaining importance on a global scale.

Figure 3 shows the academic sources (journals and publishing platforms) that have published the most on the Multiple Adaptive Regression Splines (MARS) algorithm in animal science. This chart reveals which academic journals have published the most research on the MARS model and which publication outlets are innovators in this field.

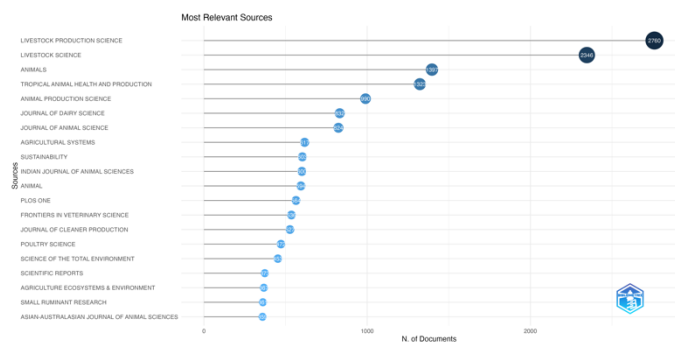


Fig. 3. Sources for MARS algorithm in animal science

The journals ranked at the top of the chart stand out as leading academic publications in the fields of animal husbandry science, biometrics, machine learning and statistical modeling. These journals give wide coverage to studies that include applications of the MARS method in animal husbandry, genetic selection, feed efficiency and live weight estimation.

The main characteristics of the sources with the most publications are as follows:

- Journals focusing on machine learning and artificial intelligence-based analyses address how the MARS model is

used to increase the predictive power in the field of animal husbandry.

- Animal science journals are among the platforms where studies on genetic improvement and feeding strategies are published.

- Statistics and data science journals include studies that examine the theoretical infrastructure of the MARS model and its applicability to different biological data sets.

These results show that research on the MARS algorithm has spread to different fields with a multidisciplinary approach and has an increasing academic interest in animal husbandry science. In addition, the identified resources provide an important reference point for researchers who want to work in this field in terms of determining appropriate publication outlets and examining the literature more systematically.

Figure 4 presents the thematic map according to author keywords used in animal science in relation to the MARS algorithm. This thematic map visualizes the clustering of keywords in the studies, how the subject areas are interconnected, and how specific research areas are grouped.

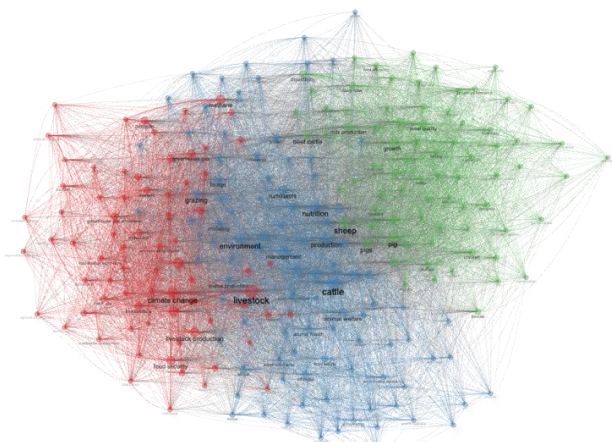


Fig. 4. Thematic map according to author’s keywords

The clusters shown in different colors in the graph represent different areas of use and research trends of the MARS model:

- Red cluster: It generally includes keywords related to basic statistical modeling, machine learning methods, and data mining. This group may represent an area where studies dealing with the theoretical background and methodological aspects of the MARS model are concentrated.

- Blue cluster: It includes keywords related to animal breeding, genetic selection, and biological performance measurements. It emphasizes the use of the MARS model in animal sciences, especially in areas such as live weight estimation, feed efficiency, and production optimization.

- Green cluster: It consists of keywords related to the effects of environmental variables, feeding strategies, and rearing conditions on livestock performance. This group may include studies showing how the MARS model is applied under different environmental factors.

The thematic map shows that the MARS algorithm has an interdisciplinary area of use in animal husbandry and can be applied to various subfields. In addition, the connections between the clusters reveal how different topics are related to each other and the interaction between research areas.

Figure 5 shows the collaboration network among researchers working on the MARS algorithm in animal science. The clusters shown in different colors represent interactions between specific groups of researchers, with the orange cluster containing the largest and most intensively collaborated group. The purple and blue clusters reflect regional or interdisciplinary research collaborations, while the green and red clusters represent smaller, more specific groups.

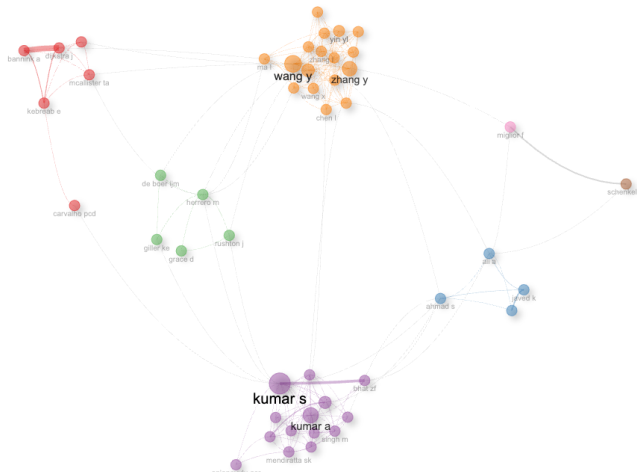


Fig. 5. Collaboration analysis

The graph shows that some central researchers collaborate with many different groups, while others work with more limited connections. This shows that the MARS algorithm has been adopted by different research groups on a global scale, but the work is concentrated around certain regions and topics. In general, it is concluded that research on the MARS model is supported by scientific collaborations and that expanding these collaborations could increase the impact of the method in animal breeding science.

The bibliometric findings show that the MARS algorithm is increasingly used in animal husbandry science, that scientific productivity for this method is steadily increasing, and that research is expanding with an interdisciplinary approach. The increase in the number of publications, the high rate of international collaborations, and the studies published in a wide range of academic fields reveal that the MARS model has become an important tool in terms of forecasting and decision support systems in animal husbandry. In addition, thematic analyses and collaboration networks show that research in this field is concentrated in certain centers, but continues to expand globally. In this context, the obtained data constitute an important resource for determining the current position of the MARS model in animal husbandry science and potential future research areas.

#### IV. CONCLUSION

This study conducted a comprehensive bibliometric analysis to reveal how the MARS algorithm has developed in terms of scientific productivity in animal husbandry science. As a result of the analyses conducted using the Web of Science database, it was determined that studies based on the MARS model have increased significantly in recent years, international collaborations are at a high level, and multidisciplinary

researches are increasingly adopting this method. Thematic mapping and collaboration analyses show that the MARS model is particularly focused on topics such as genetic selection, growth performance prediction, feeding strategies, and the effects of environmental factors on animal production. In addition, while certain academic centers and journals produce the majority of publications in this field, it has been observed that a growing research network has been formed on a global scale. The results show that the MARS algorithm has been adopted as a powerful prediction tool in animal husbandry science and will have a wider application area in the future. Therefore, it is recommended that future studies focus on further optimization of the MARS model, its integration into different animal production systems, and comparative analyses with other machine learning methods.

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