

Bibliometric analysis of the scientific production of the *Pastos y Forrajes* journal

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Abstract

Objective: To characterize the scientific production of the *Pastos y Forrajes* journal during the period 1978-2021 and its relation to the paradigm changes in the research + development + innovation (R + D + i) processes of the Pastures and Forages Research Station Indio Hatuey.

Materials and Methods: The dominion was constituted by the Pastures and Forages Research Station Indio Hatuey. Some bibliometric indicators related to the scientific production of this journal were described and evaluated. The study is classified as descriptive, longitudinal and retrospective. A total of 1 508 papers was recovered, and a database was created with the bibliographic manager EndNote X7. The analyzed indicators were the following: total published papers per year, geographic distribution, co-authorship index, collaboration networks of authors, co-occurrence networks for keywords, and most studied species. For the analysis of the thematic area the terms of the Agricultural Thesaurus AGROVOC and that of UNESCO were used.

Results: In the first stage a higher quantity of papers about the introduction, evaluation and selection of pasture and forage species and varieties aimed at livestock feeding, was published, which was in correspondence with the existing genocentric model in the period. The second stage was marked by the papers related to the use of trees for animal production, with agroecological and sustainable approach, which was enhanced with the creation of the Socioeconomics group, which had a systemic and holistic vision of research. In the last stage the topics published in the journal were broadened and diversified, not only focused on cattle, but also on other species that can utilize the forage resources and created systems, with the inclusion of socioeconomic and environmental topics.

Conclusions: The use of the bibliometric tools revealed high scientific and practical pertinence, which allowed to visualize the paradigm changes associated to the mission and the R+D+i lines. The most studied species have been *Leucaena leucocephala* and *Megathysus maximus*; while the most outstanding researched topics are: milk production, silage, nutritional value, silvopastoral systems, evaluation of plants, application of fertilizers and seed production.

Keywords: scientific production, bibliometric indicators

Introduction

Journals have played a determinant role in research management and development processes. The pioneer ones were the French *Journal des savants* and the British *Philosophical Transactions*, both published for the first time in 1665, which imposed a new writing style and ways to disseminate scientific knowledge (Bank, 2021).

Through the years journals became the main communication means of scientific research results, mainly since the mid-20th century. As a whole, they constitute the principal dynamic memory of the advance of scientific knowledge. According to Bank (2021), their production in periodical series makes up flows of scientific information in the different disciplines and thematic areas that report to researchers about the progress in their fields of interest.

At present, they constitute an instrument of the scientific community to present their works, for which it can be stated that journals are the means to evaluate the benefits of science. For such reason, they turn into an important and tangible result of research. Bibliometric studies aim at treating and analyzing such journals; their results are highly important to catalogue, classify and quantify the knowledge of a given discipline (Ferreira *et al.*, 2014). Traditionally these studies have been one of the tools used to evaluate science and its products, and, more specifically, scientific production.

Bibliometric studies play a fundamental role in decision-making in scientific policy and in the evaluations of research yield. Their application allows the institutions to establish which research lines to follow, where they should place their budget to

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guarantee development, as well as to determine the innovation possibilities within each productive sector, etc. (Herrera-Vallejera, 2016).

In 1978, at the Pastures and Forages Research Station Indio Hatuey (EPPFIH, for its initials in Spanish) the edition of the *Pastos y Forrajes* journal started, as official organ of the Ministry of Higher Education for the dissemination of scientific results in the animal husbandry field; it has been uninterruptedly published, with a total of 1 508 papers until 2021, which correspond to research works of the Station itself and from other national and foreign centers (Hernández and Ojeda, 2008).

Regarding the bibliometric aspect, *Pastos y Forrajes* has been included in some studies at macro level, conducted by the Ministry of Higher Education, or of thematic category at country level (Rodríguez-Sánchez *et al.*, 2006). Also, in studies conducted at the institution comprising previously determined periods, in which a reduced set of indicators was used (Armengol-López, 2017). For such reason, this work was conducted in order to characterize the scientific production of the papers published in the *Pastos y Forrajes* journal during the period 1978-2021 and their relation to the paradigm changes in the R+D+i processes of the Pastures and Forages Research Station Indio Hatuey.

Materials and Methods

Characterization of the dominion. Stages in the evolution of the Pastures and Forages Research Station Indio Hatuey. The dominion was constituted by the EPPFIH. In its evolution, this center has gone through stages linked to different paradigms and to their changes. In this regard, Suárez *et al.* (2001) state that when exhaustion and insufficiency to approach a phenomenon related to the emergence of a new situation occurs, a paradigmatic crisis occurs that causes the breakup and change of the existing paradigm by another new one that satisfies the current situation.

Taking into consideration the above-explained facts, the periodization of the stages was established considering the opinion of several experienced researchers. The periods were defined as follows: I. constitution and institutionalization (1962-1975), in this stage the journal was not published yet, II. growth and consolidation (1976-1989), III. age of change in the change of age (1990-2006). These periods comprised between nine and fifteen years.

Since 2008 changes occur in the mission and in the work philosophy of the institution, which were gathered in a fourth stage that has not been fully

consolidated yet; and it is foreseen that more than ten years should pass for it not only to be enhanced, but also to originate another model of institutional development. This stage IV (2007-?) was called new systemic model of R+D+i (Blanco-Godínez *et al.*, 2017).

Aggregation level. The election of the aggregation level was conditioned by the work objectives and the available data (Gauthier, 1998).

In this study, the performance of some bibliometric indicators related to the scientific production of the *Pastos y Forrajes* journal was described and evaluated, which corresponds to the meso level (Glänzel *et al.*, 2009).

Study type. The study was descriptive, longitudinal and retrospective, according to Hernández-Sampieri *et al.* (2014).

- Descriptive. Information was gathered about the variables and their performance was described.
- Retrospective. The research design included the already published volumes, with closing in 2021.
- Longitudinal. The performance of the different variables through time was followed, that is, in the different stages.

Search, recovery and processing of information. A total of 1 508 papers was recovered, which were exported in RIS format output to EndNote X7 to create the single database of the journal. The object of study was constituted by the papers published in the period 1978-2021, belonging to the volumes from 1 to 44, in which all the review and scientific papers, technical notes and case studies were compiled.

Normalization of the database. Once the elaboration of the database was finished, its normalization was done. The written accents and other marks of Spanish grammar were removed in order to prevent mistakes due to the presence of special characters, in the visualization of the different collaboration networks. It was also observed that the name of one same author appeared reflected in different ways, for which a thorough manual revision was carried out and the names were unified. In addition, in some cases the ORCID tool was used for the unique identification of the authors.

System of indicators. In the bibliometric study the following indicators were analyzed:

- Total of papers published per year. Total number of papers, but without including the reflections, the editorials and points of view. All the journal numbers were included: three per year in the period 1978-1996 and four per year in the period 1998-2020, with the

exception of 1997 in which there were only two (in the third number of that year the author, topic and species indexes were published). Since 2021 the journal became a continuous publication, with a single annual volume (without numbers).

- Total of papers per typology. The original papers from research results, bibliographic reviews, technical notes and case studies, were taken into consideration.
- Affiliation. Percentage of authors from the EEPFIH, national and foreign institution
- Authors' productivity. Authors with the highest number of works per stage.
- Co-authorship index. It was obtained dividing the number of authors per year by the number of published works.
- Authors' collaboration networks. Collaboration relations among the identified authors, as well as their intensity. The work started from an authors' co-occurrence network, using the Bibexcel tool version 2017. For the visualization of the networks the software Pajek version 64 5.01 (Mrvar and Batagelj, 2017) was used, and the design Energy/Kamada-Kawai/Separate components for a better utilization. The co-authorship matrices were made up with the authors who showed six or more co-occurrences.
- Co-occurrence networks for keywords. for the visualization of these networks the software VOSviewer version 1.6.16 (Eck and Waltman, 2020) was used.

Results and Discussion

The bibliometric analysis of the papers published in the *Pastos y Forrajes* journal was contextualized in

the framework of the previously-described stages through which the EEPFIH evolved.

Stage 1978-1989. Growth and consolidation. In this stage 377 papers were published; from them, 87,2 % (329) were scientific papers, 10,0 % (38) review papers and 2,6 % (10) short communications. The highest quantity of review papers contained the description of one species or one genus (24); of them 15 dedicated to grasses, 8 to legumes and 1 about trees. The years with the highest quantity of published papers were 1987 and 1989 (35), followed by 1986 (34), 1980 and 1988 (33 in each one).

Figure 1 shows the co-authorship index in the period, which was of less than two authors per paper; this can be considered low, according to the report by Rodríguez and Area (2016). The highest value was 1,94 in 1987, and in the other years it oscillated between 1,26 and 1,72 authors per paper. Most of the collaborations corresponded to authors from the EEPFIH alone. This was due to the high specialization of the different disciplines, the lack of an inter- and multi-disciplinary approach of research and the non-existence of policies that promoted the funding of science in work groups.

The dissemination of science through scientific papers produces a series of relations among researchers, which establishes collaboration networks; in them, the nodes represent authors who are connected by a line, if they have jointly signed one or more works. Such authors' collaboration network, called "invisible college" (Paz Enrique and Núñez-Jover, 2021), is the most visible form of scientific collaboration; for which it is frequently used to measure collaboration among authors, and it is also an indicator to analyze

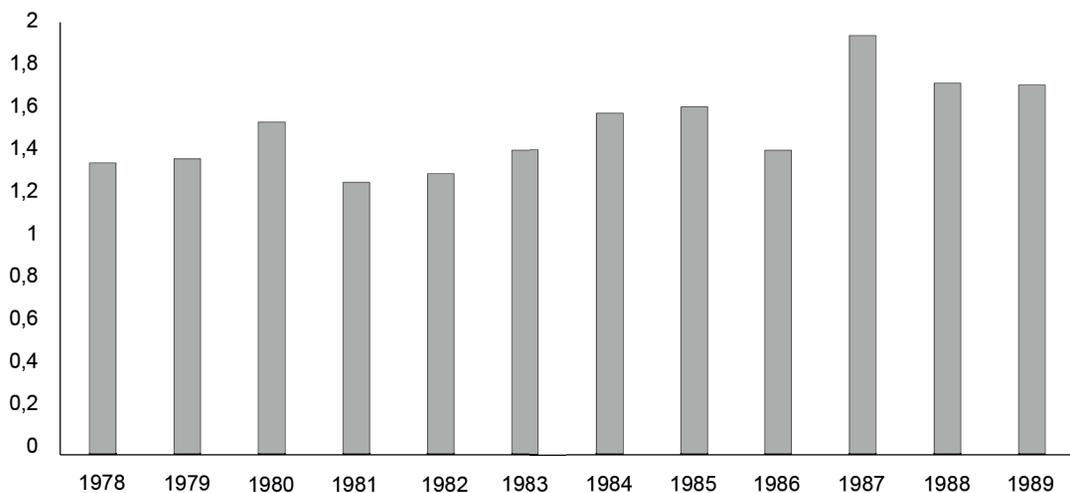


Figure 1. Co-authorship index (1978-1989).

the collaboration networks (Rodríguez-Gutiérrez and Gómez-Velasco, 2017).

Figure 2 shows a network of relations which, due to its numerous inputs, it was necessary to simplify it to six or more signatures for a better visualization. Thirty nodes in total can be identified. The most intense collaboration was the one by Esperanza Seguí and Hilda Machado, with published papers about breeding of the species *Panicum maximum*.

On the other hand, O. Cáceres, H. Santana, M. Esperance, R. García-Trujillo and F. Ojeda established a strong collaboration regarding the study of the nutritional value of several grass species after being preserved, silage microbiology and hay elaboration.

The intense relation of V. A. Remy, J. Martínez and Milagros Milera was also noteworthy, with papers about the agrotechnical aspects and milk production of the species *Cynodon dactylon* (L.) Pers and *Lablab purpureus* (L.) Sweet cv. Rongai, mainly. The relation between A. Pérez and C. Matias was also outstanding, with works about the effects of planting method and density, harvest moment and fertilization, on grass seeds. On the other hand, M. Tang and J. Menéndez also had strong collaboration on the topic of *Rhizobium* inoculation in the legumes *Macroptilium atropurpureum* (DC.) Urb., *Teramnus labialis* (L. f.) Spreng., *Centrosema pubescens* Benth., *Stylosanthes guianensis* CIAT-184 (Aubl.) Sw. and *Leucaena leucocephala* (Lam.) de Wit. Another important relation was the one established between A. Alfonso and L. R. Valdés in publications about the effect of stocking rate and fertilization on beef production.

From the above-described facts it is concluded that the knowledge of networks is important because it allows to visualize work groups (Bedoya-Marrugo *et al.*, 2018). From the collaboration among authors a relational structure emerges that helps understand, manage and predict the results of the scientific production generated by groups of co-authors (Corrales-Reyes, 2017).

Regarding institutional collaboration, from the 377 published papers 348 (92,3 %) were exclusive of the EEPFIH (fig. 3). Works from 19 affiliations were identified, 17 of them of Cuban institutions (89,4 %). From them, the Institute of Animal Science (ICA) was the second most represented national institution in the stage, with 14 papers, 9 as single affiliation and 5 in co-authorship (4 with the EEPFIH and 1 with CENSA). Only one paper of a foreign institution as main author (0,2 %) was published, belonging to the Agricultural Research Center of North Torreón –Coahuila, Mexico–.

According to Piedra-Salomón (2015), the co-occurrence of keywords allows to identify the thematic content of the papers; while the visualization of it from networks provides a more comprising and integral view of the most approached topics and the relations among them.

Forty six keywords with six or more mentions were used, from a total of 242 utilized ones. The most mentioned terms were: '*Panicum maximum*', '*Cynodon dactylon*', '*Digitaria decumbens*', 'silage' and 'application of biofertilizers'. These, along with 'plant evaluation', 'nutritional value' and 'forages', among others, are the ones with the highest co-occurrence among them (fig. 4). '*Cynodon nlemfuensis*', '*Cenchrus ciliaris*', '*Pennisetum purpureum*' and '*Chloris gayana*' were also within the most mentioned ones (fig. 4). This is a reflection of the consolidation of the organizational model of the scientific work of genocentric character, in which obtaining pasture and forage species and varieties constituted the center of the research activity of the EEPFIH (Blanco-Godínez *et al.*, 2017).

These pasture and forage species were evaluated due to the scarcity of endemic or naturalized grasses which were adequate for animal feeding, and the studies included the comparative evaluation and management of the different species (fig. 5). Papers were published about the planting season, moment, distance and density, which allowed to have information about the aspects to be considered for good pasture establishment.

It is also important to make emphasis on the publications about collections carried out throughout the country, which contributed to the adaptation of the pasture and forage regionalization policy. These studies were also conducted in plants of the legume family, not only in grasses (fig. 6).

In the stage results were published about the application of fertilizers, fundamentally the potassium and phosphorus sources, as well as the determination of the critical P and K levels in several grasses and legumes. In addition, the topic of the nitrogen levels in different species and accessions was also exhaustively approached.

Another treated aspect was the study of native *Rhizobium* strains, where the legumes belonging to the genera *Neonotonia*, *Macroptilium*, *Stylosanthes* and *Teramnus*, were identified, among others, as capable of nodulating effectively. On the other hand, interesting results were published about the inoculation of *Rhizobium* strains in *L. leucocephala* (fig. 6).

Regarding seed production, papers were published related to yield, drying, processing and storage

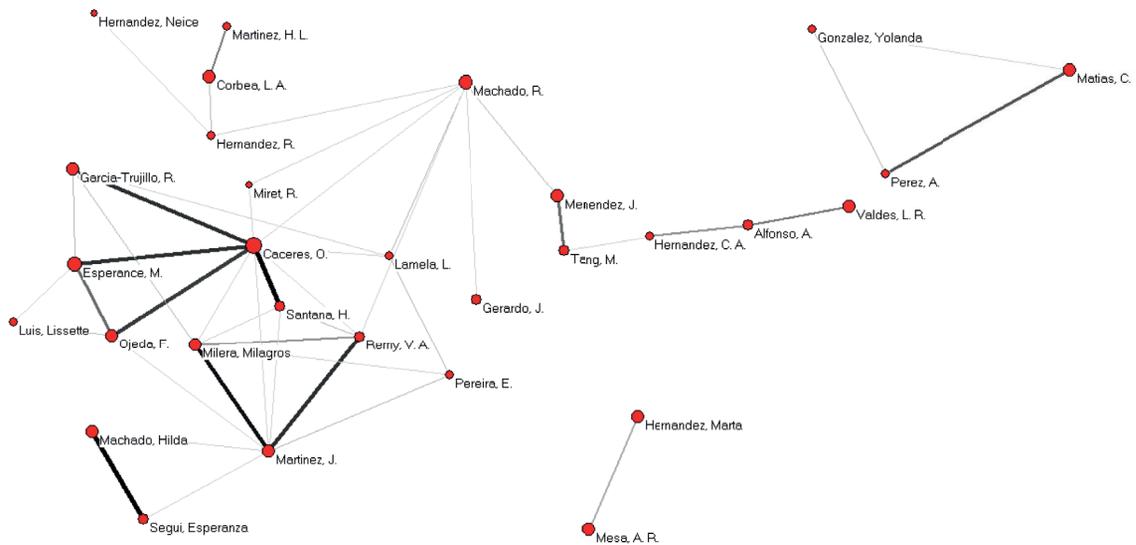


Figure 2. Network of collaboration among authors (1978-1989).

of pasture seeds, as well as to the scarification and germination methods in grasses and legumes.

A high number of papers was published about silage elaboration, use of chemical and biological additives in silage elaboration, its use in the diet of different animal types, as well as its incidence on milk production (fig. 7). Besides, about the determination of the nutritional value of multiple forage species. Studies were also conducted related to the obtainment of autochthonous lactic strains, which improve the fermentative quality of silages and their digestibility by the animals; and also about the elaboration of high-quality hay from different grass species.

In this stage the first studies with *L. leucocephala* were conducted and the first results of a multi-associated system of grasses and legumes, which used leucaena as shrub component, were obtained. The utilization of herbaceous and tree legumes, associated to grasses, which was presented as a new result for the tropic, was also promoted.

The effect of fertilization and stocking rate on meat production using different species, such as the grasses *P. maximum*, *C. dactylon* and *Digitaria decumbens* Stent associated with the legumes *Neonotonia wightii* (Wight & Arn.) JA Lackey, *M. atropurpureum* and *T. labialis* and with inclusion of the tree *L. leucocephala*, was a novel aspect treated in the publications of the period and which marked guidelines for the later stage.

With regards to milk production, different species were evaluated and managed with different levels of fertilization and stocking rate, in diets that

included silages and forages indistinctly. In that sense, the most studied species were *C. dactylon*, *D. decumbens*, *P. maximum* and *Pennisetum purpureum* (Schumach) (Wight & Arn.).

The most disseminated species in the stage was *P. maximum*, with 84 papers. The creation of the Breeding group in 1977, which focused its work on the breeding of such species, contributed to this (Blanco-Godínez *et al.*, 2017). The studies were aimed, mainly, at the creation of varieties of high general productivity and high quality of their protein.

C. dactylon (54 papers) and *D. decumbens* (44), which were widely evaluated and agronomically studied, also stood out; followed by *C. ciliaris* (25), *P. purpureum* (23) and *C. nlemfuensis* (22). *N. wightii* (16) was the most researched legume in the stage, along with *M. atropurpureum* (12) and *L. purpureus* (10). Special mention is deserved by the 7 papers in which *L. leucocephala* appears, due to the importance this species had in the next stage.

Stage 1990-2006. Age of change in the change of age. In this stage 599 papers were published; from them, 84,8 % were scientific papers (508), followed by review papers which represented 9,3 % (58), and short communications, 5,5 % (33). Likewise, as a product of a change in the research model the editorial criterion that the research papers were fundamentally dedicated to one genus or species was abandoned, and they acquired a more systemic approach (Blanco-Godínez *et al.*, 2017). For the first time, although in very low quantity, other paper types appear, such as points of view (3), case study (2) and reflection (2).

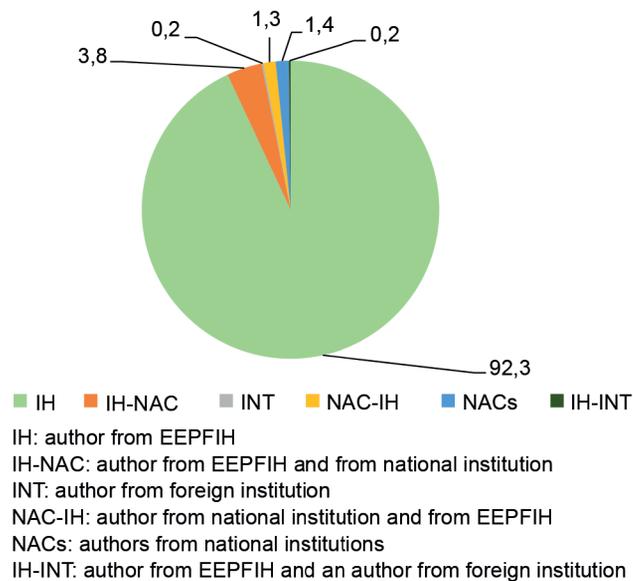


Figure 3. Percentage of national affiliation and foreign affiliation (1978-1989).

Since 1998 the journal changed its periodicity from four-monthly to quarterly. The years in which more papers were published were 1998 and 2004, with 45 in each volume, followed by 1993 and 2003 (43) and 2001 (40). The year in which less papers were published was 1997 (16), because the first number of that year was dedicated to a special edition with four papers, and number 3 to an index of titles, authors, topics and scientific names of genera and species, which included from volume 1 to number 2 of volume 20.

In general, an increase was observed in the co-authorship index (fig. 8) compared with the previous stage, in which it was low (not higher than 2). This index varied between 1,32 and 2,84. It should be emphasized that, in the last 7 years, in most cases the co-authorship index was of more than 2 authors per paper, although there was no constant growth (fig. 8). Rodríguez and Area (2016) state that it should be higher than 2 to be considered good.

Figure 9 shows the authors' collaboration network, formed by 68 nodes. It was also necessary to simplify it to six or more signatures due to the large quantity of inputs, in order to improve their visualization. This increase in the quantity of authors with regards to the previous stage was related to the multi-disciplinarity derived from the systemic approach of the studies, as well as to the changes occurred in the editorial policy of the journal to increase its quality, among which the following can be cited: broadening of the topic spectrum; celebration

of experience exchange workshops, due to the 20th and 25th anniversaries of the journal; and visit of representatives of the editorial of the MES, when the need to increase the publication of papers from authors of other institutions was suggested in order to increase visibility.

The most intense relation was the one between O. Cáceres and E. González, through the papers about the determination of the nutritional value in forage trees and shrubs, with ruminants, with neither irrigation nor fertilization in both seasons of the year.

L. Simón established very strong work relations with I. Hernández and Mildrey Soca, on the topic of silvopastoral systems; also, with Ana G. Francisco, J. M. Iglesias, L. Lamela and Marta Hernández. Together, they published papers related to the agronomic management of trees and shrubs, the study of gastrointestinal nematodes in cattle, milk and meat production, among others.

On the other hand, Marta Hernández, F. Reyes, A. R. Mesa and Saray Sánchez had intense collaboration on the topic of agrotechnical works in grasses and legumes; besides, in their association with trees and with *Morus alba* L., as well as in the study of the soil fauna.

L. Lamela, Tania Sánchez and O. López, who conducted studies about milk production using silvopastoral systems, also had intense collaboration.

Hilda Machado, A. Suset, Leybiz González, Taymer Miranda and Maybe Campos established

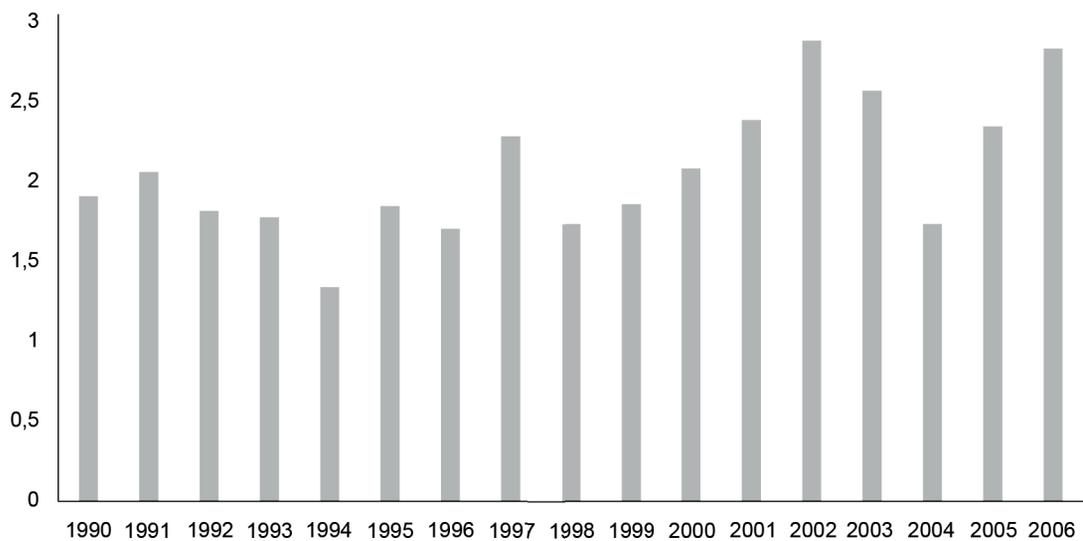


Figure 8. Co-authorship index (1990-2006).

included forage shrubs and trees gained space (Blanco-Godínez *et al.*, 2017). This was proven in the thematic performance of the journal in the period.

Seventy six keywords were used six or more times, from a total of 566 terms. The papers about the introduction of pasture and forage species continued to be published, mainly about the collection and evaluation of tree species, which enhanced the scientific works about the use of silvopastoral systems, and also about herbaceous species, because they constituted important part of the systems (fig. 11).

Regarding seed production, results were published about the utilization of biotechnological methods to increase germination, as well as about new techniques to increase this indicator in aged seeds (fig. 12). The use of such techniques, from the environmental point of view, contributed to the reduction of the use of chemical products (Blanco-Godínez *et al.*, 2017), aspect in agreement with the adoption of an agroecological and sustainable vision of the studies at the EEPFIH in this period.

In addition, papers were published about planting density and distance, influence of pruning height and frequency on seed production and quality, effect of storage and pre-germination treatments on seeds from several grasses, as well as the performance of germination and viability of legume seeds during storage under ambient conditions.

In this stage papers were published related to the cutting height and its effect on biomass yield and regrowth, fundamentally in *L. leucocephala*

and *Albizia lebbek* (L.) Benth, species aimed at forage production in the dry season (fig. 13).

The effect of the inclusion of trees and shrubs on soil amelioration and on the productivity of forage grasses was also studied in the stage, taking into account the contribution made by trees through the atmospheric nitrogen, nutrient recycling and stimulation of biological diversity.

Results from studies in tree species were published, with emphasis on their positive effect on grass yield and the productive results of the animal component, with which the potentiality of silvopastoral systems was proven.

Other studies dealt with the addition of tree foliage in the pastureland, which led to the increase of the grass biomass and showed a positive effect on the community of the soil macrofauna.

The publications about the study of the entomofauna associated to silvopastoral systems based on *L. leucocephala* and *P. maximum*, fundamentally, as well as their contribution to the increase of the edaphic fauna were also a reflection of the paradigm change in research at the EEPFIH.

With the change that occurred in the work style in the stage, the application of minerals for plant nutrition decreased. An agroecological and sustainable concept was adopted, according to the systemic approach, and the papers about the use of biofertilizer microorganisms (*Azotobacter*, *Azospirillum* and mycorrhiza strains) had an important presence in the period.

Regarding the papers that approached the topic of conservation, the ones related to the utilization of ammonified

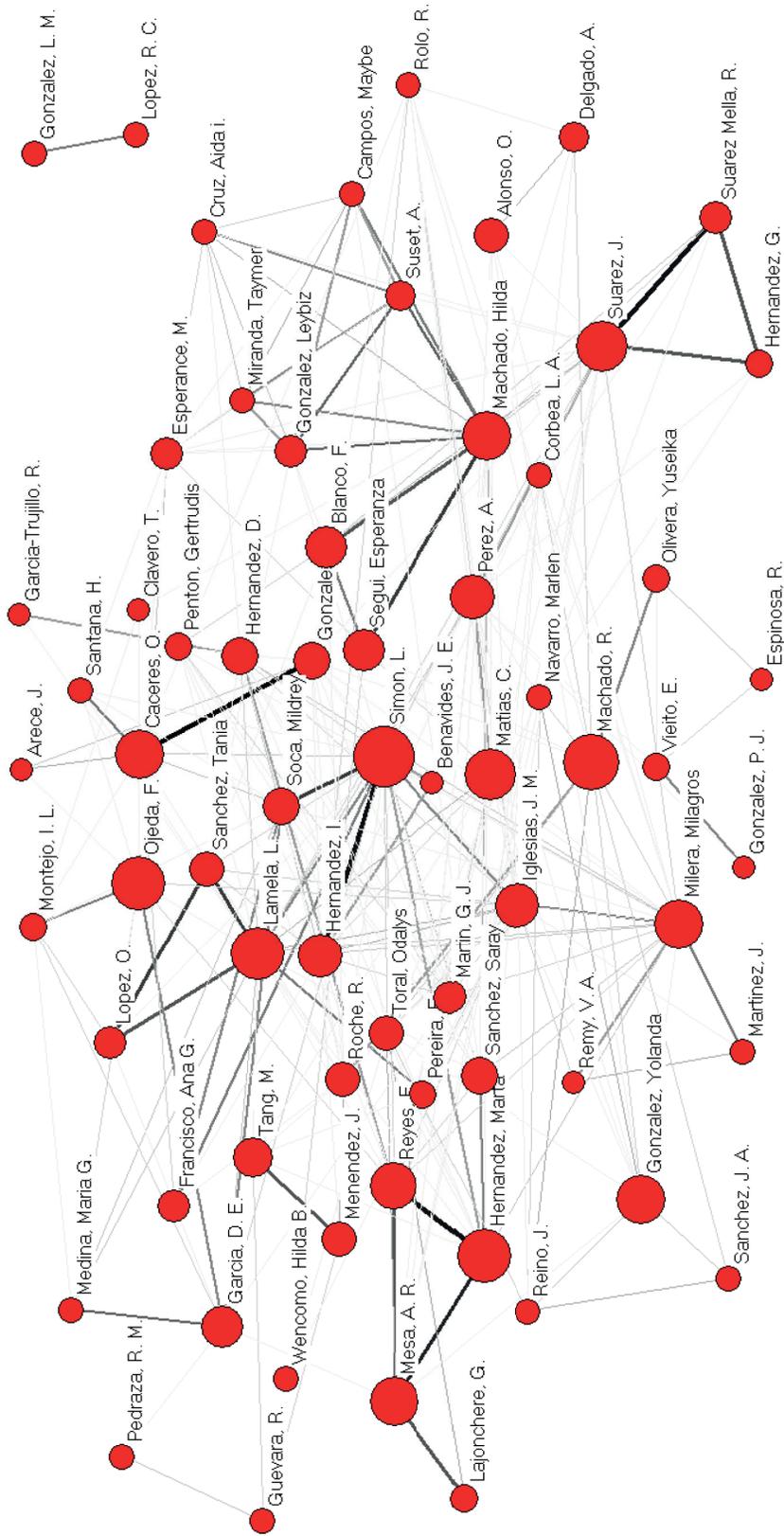


Figure 9. Network of collaboration among authors 1990-2006

molasses as supplement for cattle; those of citrus pulp conservation, preserved with different materials; and the ones on elaboration of silages of citrus pulp, sugarcane and mulberry, were very important.

The works about nutritional value also had an important presence, mainly those of determination of this indicator in trees. It must be emphasized that in number 2 of volume 23 (year 2000) the nutritional value tables were published, which comprised practically all the utilizable forage resources in the country. The publication of such tables was product of the high demand of this information by the students of the Master of Sciences program in Pastures and Forages and by the feeding specialists of the animal husbandry enterprises of the country.

Taking into consideration the new vision of research in this stage, the studies were re-aimed at tree plant health, fundamentally in *L. leucocephala*. The associated diseases were studied in a collection of 170 accessions of this legume; besides, the evolution of the bacterium *Erwinia* sp. in *L. leucocephala* and the mycobiota in stored seeds.

The use of silvopastoral systems, according to the new paradigm implemented at the EEPFIH in this stage, also influenced the publication of papers about milk and meat production, derived from studies about the use of protein banks and associations of different woody plants and pastures, as well as management methods for fattening as well as for rearing replacement cows (fig. 13). Thus the potentiality of these systems for such purpose with different genotypes was proven, in areas of the EEPFIH as well as under production conditions.

The results in silvopastoral systems also generated papers about the resistance of the different breeds to parasitism and integral control of gastrointestinal nematodes in ruminants in animal husbandry systems. Aspects about etiology; the biological cycle; geographical location, development, survival and migration of infesting larvae to the environment; as well as the role of zootechnical factors in these parasite diseases, were also published.

Highly important are the works about *M. alba* that began to be published by the late nineties. This plant produces high-quality biomass, and has high potentiality for feeding different animal species (Blanco-Godínez *et al.*, 2017). Studies were conducted about the effect of cutting height and frequency on biomass production, intercropping of herbaceous legumes in the period of plant establishment, bromatological composition and fertilization doses.

Likewise, the affectation of the species by fungi, influence of inoculation with *Azotobacter chroococcum* combined with different sources of organic matter, an detection of secondary metabolites through the utilization of phytochemical sieving, were evaluated. The effect of organic fertilization on the quantitative variations of the main secondary metabolites present in different varieties of *M. alba*, were researched.

Also, the community of invertebrates in an association system of *M. alba* with legume trees, and the alternative of depositing the mulberry foliage on the soil to achieve higher density and diversity of invertebrates in the system, were determined.

In this stage the first publications about socio-economic aspects appear (fig. 14). An approached topic was the introduction of silvopastoral systems in Havana province to enhance, with multidisciplinary approach, the extension of silvopastoral systems in the country.

Besides, studies were published, from the sociological perspective, of the factors that mediate and/or hinder the technology transference process towards the animal husbandry sector. Such aspects as the loss of animal husbandry costumes and habits, the structure of animal husbandry organizations, both essentially related to the social actors who participate directly or indirectly in the technology introduction-adoption process, were analyzed.

The outreach and way of the participatory development alternative from the self-management in their productive entities in Matanzas province were also analyzed. Likewise, papers were published about socioeconomic and environmental diagnoses with the participation of the dwellers in the Martí municipality, in communities and entities linked to animal husbandry, in order to contribute to sustainable development in a rural community.

Regarding the species, *P. maximum* continued to be the most studied in such aspects as: breeding, establishment, fertilization levels, seed production, diseases, nutritional value, preservation in the form of silage, its use for milk production, as well as its evaluation associated to other grasses, legumes and trees.

The increasing interest for the shrubby legume *L. leucocephala* was shown in the published papers, specifically in the results of the multi-associated system of grasses and legumes that used leucaena as shrub component.

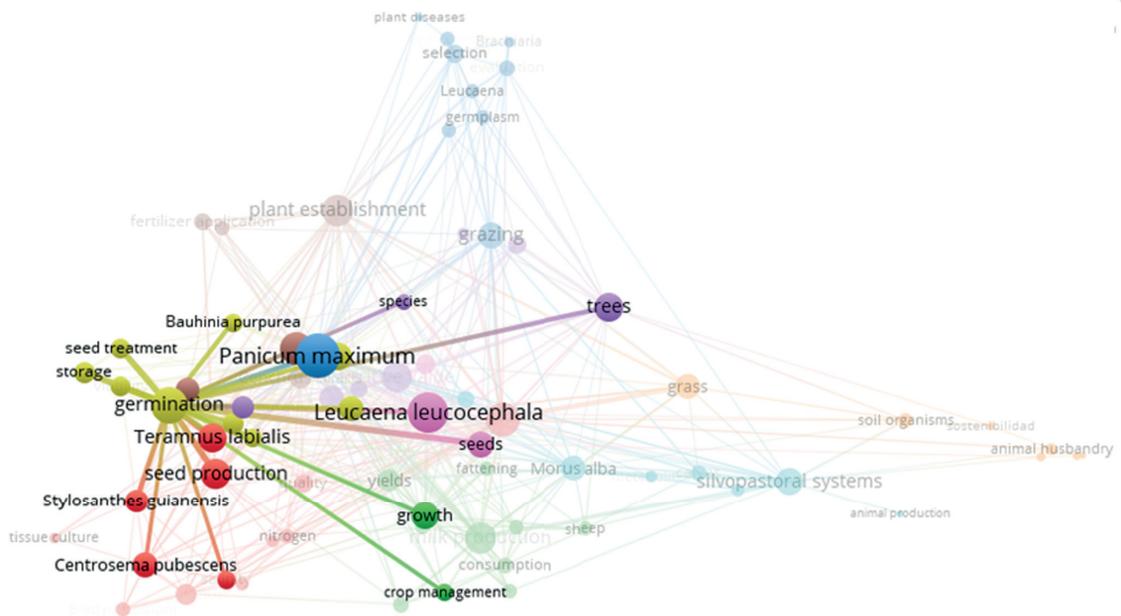


Figure 12. Indicator 'keywords': Seed production.

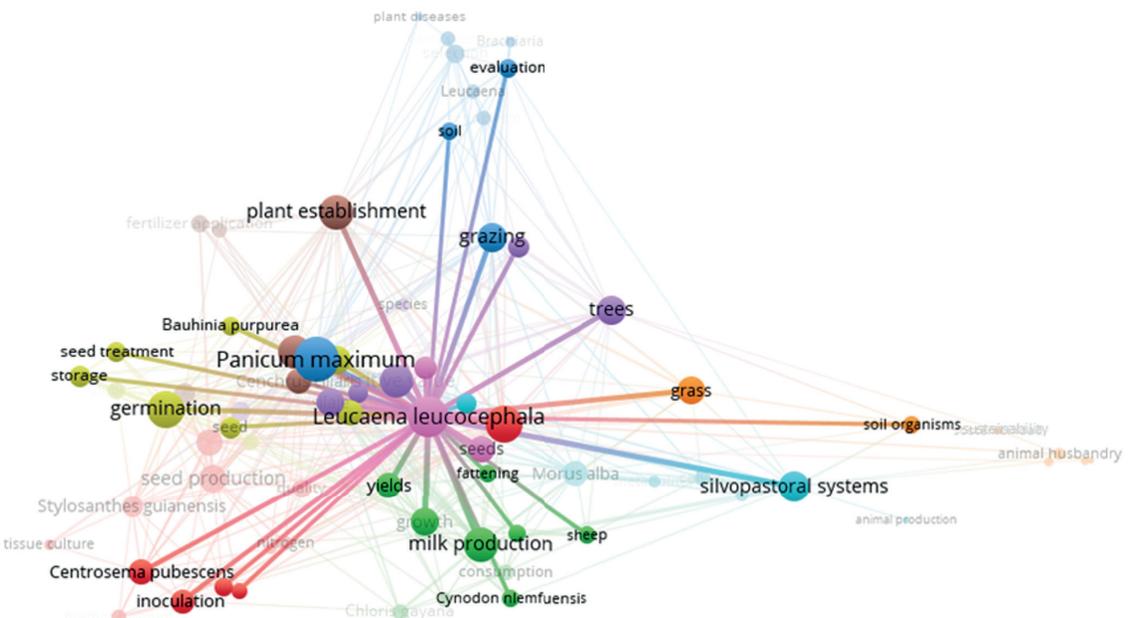


Figure 13. Indicator 'keywords': Use of trees.

It should be emphasized that the trees were also included among the most researched species; thus, the publication of papers about *L. leucocephala*, *M. alba*, *A. lebeck* and *Gliricidia sepium* (Jacq. Kunth ex Walp.) increased.

Stage 2007-2021. Consolidation of the new systemic model of I+D+i management. In the period

2007-2021 the agroecological perspective continued to gain adepts. Most of the research centers linked to the agricultural sector prioritized agroecological studies.

The *Pastos y Forrajes* journal went through important changes in its content and format; the topics were broadened, all the volumes with their

corresponding numbers were digitalized, it was inserted in SciELO – Scientific Electronic Library Online, and acquired higher prestige and visibility.

Between 2007 and 2021 a total of 556 papers were published; from them, 476 (85,6 %) scientific papers, 42 (7,5 %) review articles, 32 (5,7 %) short communications and 4 (0,7 %) in the analysis section. The years with the largest quantity of papers (40) were from 2016 to 2020, in the rest of the stage the quantity varied 34 and 37 papers per year.

The co-authorship index surpassed that of the previous two stages, and in all the years it was higher than 2 (fig. 15). In this period it varied between 2,45 and 4,37; which shows higher collaboration among authors with regards to the previous stages.

Regarding the authors' collaboration network, figure 16 shows that the most intense work relation occurred among L. Lamela, Tania Sánchez and O. López, in papers about the use of silvopastoral systems for milk production and of the body condition of females at parturition using *L. leucocephala* and *M. alba*. L. Lamela and O. López also had a strong relation with I. L. Montejo, in works about the use of protein supplementation sources.

In papers that approached agronomic aspects of *M. alba*, G. J. Martín, Gertrudis Pentón and Yolai Noda had an intense relation. G. J. Martín also had strong collaboration with Milagros Milera, in papers related to the scientific policy and the organizational models of science, and with J. Suárez, in publications about the project BIOMAS-Cuba.

In works about animal health and the use of probiotics in sheep, J. Arece and Y. López maintained a close relation; just like O. Alonso and J. C. Lezcano in papers about the presence of fungi in *L. leucocephala* seeds. Likewise, the close relation of the previous stage was maintained in the case of Hilda Machado with Taymer Miranda, A. Suset, Katerine Oropesa and Maybe Campos, in works about innovation, rural and local development.

Saray Sánchez, Marta Hernández and G. Crespo published about the decomposition of litter in silvopastoral systems; F. Ojeda, Mildrey Soca and E. R. Canchila about the agronomic evaluation of *Brachiaria decumbens*; Yolanda González, J. Reino, J. A. Sánchez and Laura Montejo regarding treatment of seeds, mainly from trees.

On the other hand, in this stage authors from 285 affiliations published, besides the EEPFIH, which continued to be the most represented one with 51 %, as single affiliation as well as in co-authorship with other institutions (fig. 17).

In order to analyze the thematic performance of the journal in this stage, it is necessary to start from the fact that the EEPFIH maintains the systemic approach in its studies, because it offers confidence to the interested parts regarding coherence, efficacy and efficiency of the organization (Blanco-Godínez *et al.*, 2017).

This is the stage in which, proportionally, a higher quantity of terms was used compared with the previous stages, as consequence of the systemic approach and integration of the studies, because there was interdisciplinarity and higher combination of the knowledge from different fields to face the specific scientific problems.

Figure 18 shows the network of co-occurrence of keywords; of 706 in total, 72 were used six or more times. The most published topics in the period were the use of trees (fundamentally *L. leucocephala*), associated to other species for the establishment of silvopastoral systems, and milk and meat production.

In the stage, the papers about plant evaluation not only approached the topic of the shrub and tree germplasm, but also their use as biodiesel producers and medicinal plants. In addition, morphological evaluations were conducted in *Brachiaria* collections on moderate-fertility and acid soils. Regarding the shrub legumes, *Leucaena* accessions were evaluated, in order to select the most outstanding to be used in or promote silvopastoral systems. Another studied tree was *Moringa oleifera* Lam, with the objective of characterizing it morphologically under nursery conditions, as well as to evaluate the affectation by fungi (fig. 19).

Of the species *Jatropha curcas* L. its provenances were characterized, which showed marked variability, from the morphological as well as from the seed production point of view (fig. 20).

Tree seed production continued to be a widely published topic, and *L. leucocephala* stood out regarding: germination, treatments, storage, fungal agents that affect it, viability and ageing, among other aspects. In addition, works were published about *A. lebbbeck*, *Urochloa mutica* (Forssk.) T.Q. Nauyen and *G. sepium*, as well as other species.

The potentiality of probiotics to improve the digestibility of nutrients was study, also, their effect on sheep, on the productive performance and health of grazing calves, as well as on the nutritional value of citrus pulp silages preserved with absorbent materials.

The valuation of sustainability in rural areas, decision-making, strategic management models, the role of managers in the productive process, conservation of

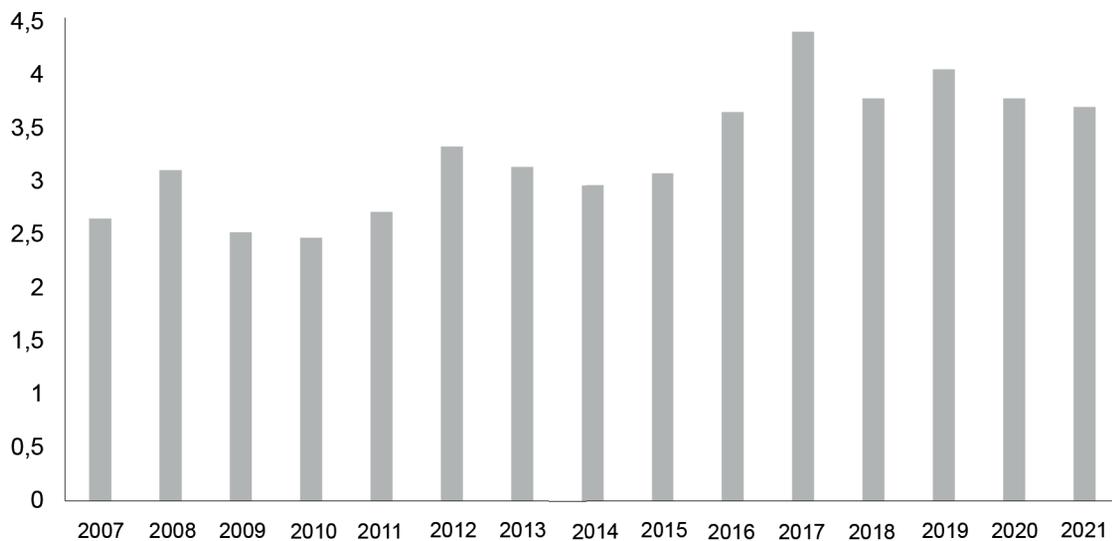


Figure 15. Co-authorship index (2007-2021).

group, papers with a social, holistic and interdisciplinary approach in research began to be published.

In the last stage, the papers continue to be a reflection of the systemic approach in the studies. The topics published in the journal were broadened and diversified, not only aimed at cattle, but also at other species that can utilize the forage resources and the created systems, including socioeconomic and environmental topics.

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Conflict of interests

The authors declare that there is no conflict of interests between them.

Authors' contribution

- Nayda Armengol-López. Generated the idea of the research, searched for bibliographic information, wrote and revised the manuscript.
- Tania Sánchez-Santana. Contributed with the idea of the research, wrote and revised the manuscript.

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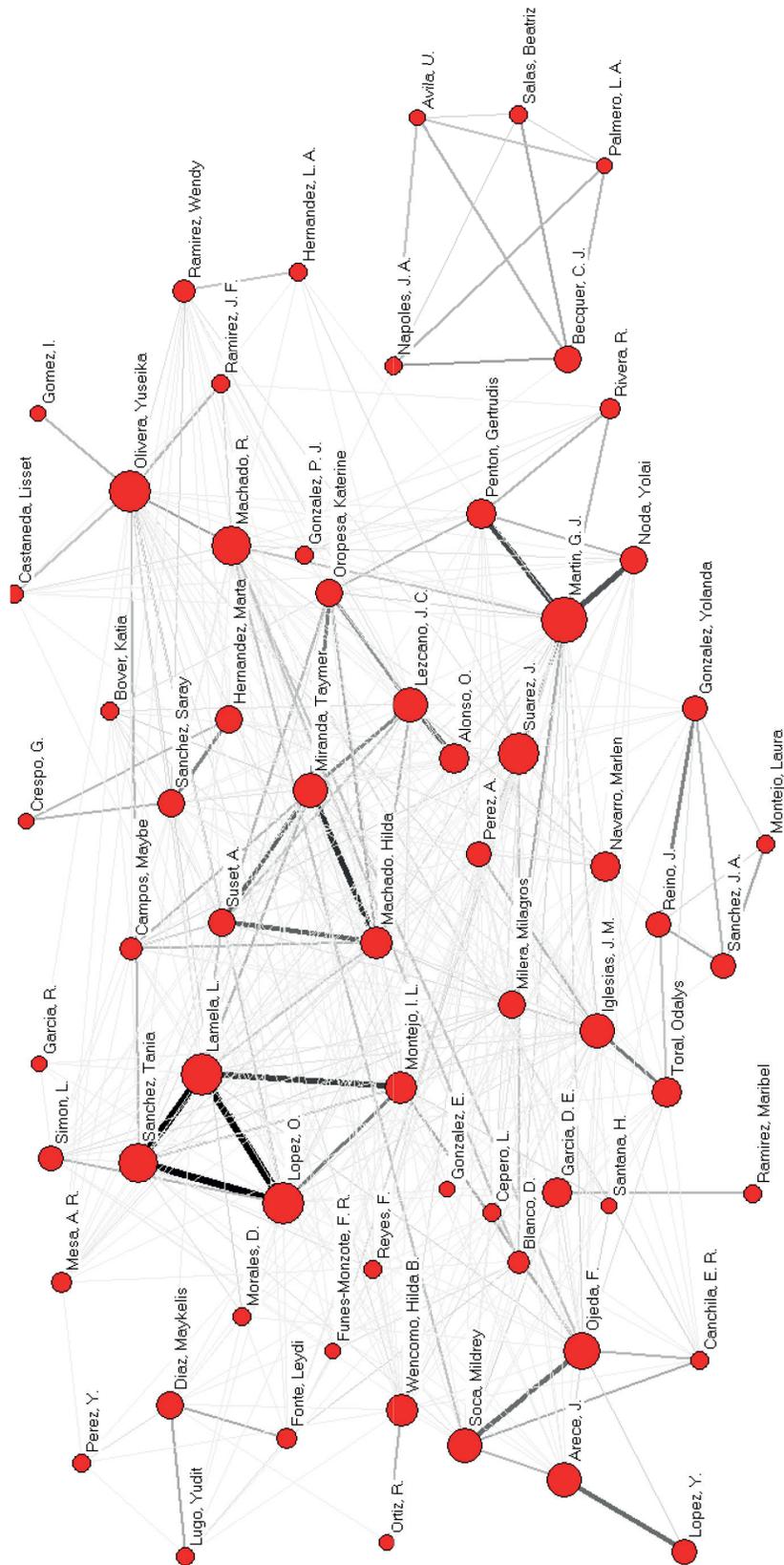
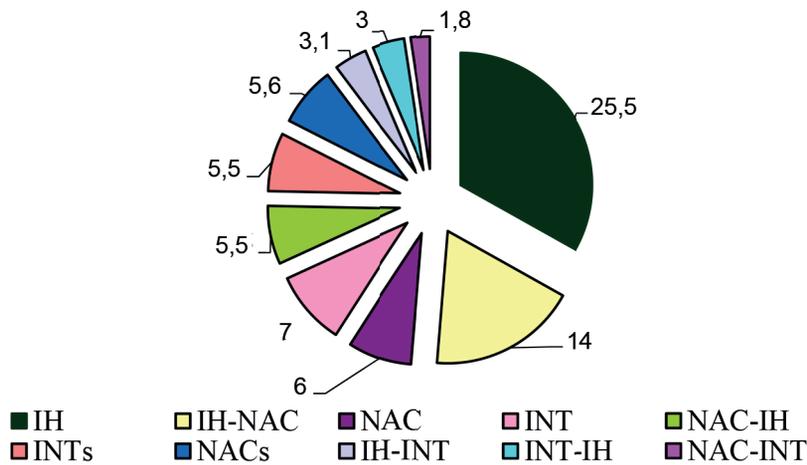


Figure 16. Network of collaboration among authors (2007-2021).



IH: author from EEPFIH
 IH-NAC: author from EEPFIH and a national institution
 NAC: author from national institution
 INT: author from foreign institution
 NAC-IH: author from national institution and from the EEPFIH
 INTs: authors from foreign institutions
 NACs: authors from national institutions
 IH-INT: author from EEPFIH and an author from foreign institution
 INT-IH: author from foreign institution and author from EEPFIH
 NAC-INT: author from national institution and author from foreign institution

Figure 17. Percentage of national affiliation and foreign affiliation (2007-2021).

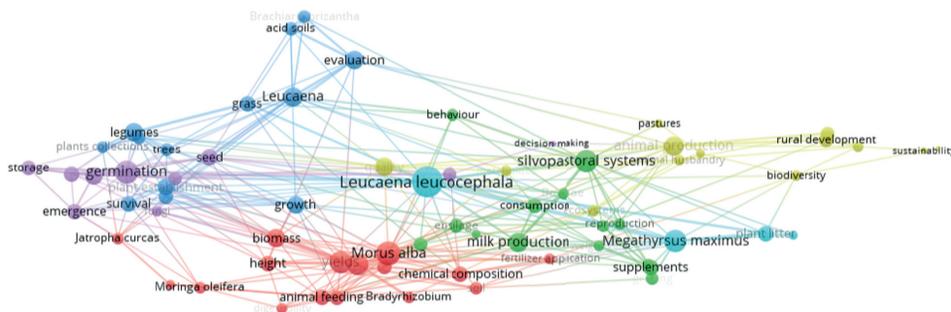


Figure 18. Co-occurrence network of keywords (2007-2021).

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