https://dx.doi.org/10.22161/ijaers.6.2.17 ISSN: 2349-6495(P) | 2456-1908(O)

Technological productivity on control of *Boophilus Microplus* tick: A Patentometric Study

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***Abstract*—** *The Boophilus Microplus tick is responsible for causing large losses in cattle, its control is based on the use of chemical products and this species has presented an increasingly resistance to the products used. The objective of this article is to evaluate the technological profile for the control of the Boophilus Microplus tick through a patentometric study. In order to identify the study, we used the patents of Espacenet and Derwent Innovations Index, where 514 patents were found and 245 were analyzed. The Vantage Point® software was used to identify the temporal evolution, the collaborative network between the researchers and the geographical distribution. It was concluded that the studies identified are of great relevance for the control of ticks, considering that technological publications are important markers of production activity and development of the field of knowledge*

***Keywords*— control, patentometry, patents, technological production, ticks.**

I. INTRODUCTION

One of the global problems are parasitic diseases, being considered a huge hindrance both in health as in the performance of the animals. Whereas the group of ectoparasites, ticks are the biggest responsible for numerous losses. The ticks directly affect the cattle, causing skin problems, wounds, weakening the animal to secondary infection, causing toxicosis and sometimes paralysis (Schroder and Reilly, 2013). Indirectly they act as vectors of fatal diseases (babesiosis and theileriosis), as well as the high cost to fight and control it (Jongejan and Uilenberg, 2004).

Given this assumption, it is critical to leveraging information on the subject, through the promotion and dissemination of the intellectual structure of their technological productions related to the control of Boophilus Microplus tick, through a patentometric study. This is used to track technological trends in several emerging fields of technology; it allows transferring data contained in patent documents in systematic and valuable information (Chang; Wu; Leu, 2010). For Macias-Chapula (1998, p. 137), "the patent number reflects the trends of technical changes over time and assesses the results of the resources invested in research and development (P&D)". The author adds that the patent indicators determine the approximate degree of the technological innovation of a country and that the number of citations of patents measure the impact of technology (Macias-Chapula, 1998).

The tracking of new technologies is extremely important, as well as the protection of intellectual property through patent document. Companies should carefully track technological innovations in this scenario that is characterized by the steady release of new products and the planned obsolescence (Hertz and Parikka, 2012).

The present article sought to assess the technological publications related to the control of Boophilus Microplus tick aiming to use patentometric techniques, seeking to highlight the researchers, companies, the geographical distribution of technological production, as well as build a network of collaboration among researchers.

II. THEORETICAL REVIEW

2.1 *Boophilus microplus*

The Rhipicephalus (Boophilus) microplus is one of the most widely distributed ticks in the world, is the main cattle ticks, being responsible for major losses in Brazilian cattle (Seixas et al., 2012), causing direct and indirect damage to animal health, limiting considerably the productivity (Cruz et al., 2014).

The parasite control relies mainly on the use of chemical acaricides that are produced from a limited set of molecules. These drugs induce the selection of ticks resistant to acaricides and are an important source of

https://dx.doi.org/10.22161/ijaers.6.2.17 *ISSN: 2349-6495(P) | 2456-1908(O)*

environmental pollution (Seixas et al., 2012). Taking into account the reports of resistance, many studies have been conducted to try to control the cattle tick through alternative methods (Santos et al., 2012).

The use of acaricides is the primary method of control in Brazil, which are not always used appropriately (Rocha et al., 2006). It is known that resistance is one of the main contributing factors in the selection of individuals due to failures in conservation, dilution and application of the products with time interval and methods that lead to non-lethal concentrations used on ticks (Furlong et al., 2007).

Currently, the are several strategies to coontrol the tick. One is the application of diferente formulations of acaricides. Another is a vaccine and also the rotations between catlle and crops. (Fao, 2004). Among these, the chemicals tickcides offer a quick and economic mitigation, constituting the basis of control to eradication. Prolonged use associated with the misuse has a downside to make these species more resistant, reducing the ability to control the infestations (Khajuria et al., 2014; Singh et al., 2014).

Therefore, it becomes necessary to seek alternatives that are adaptable and less expensive, especially for farmers who has limited means and who make up the bulk of animal breeders in developing countries, including Brazil. Several studies have been conducted to develop environmentally safe control measures against ectoparasites (Abdel-Ghaffar and Semmler, 2007; Rawani et al., 2010; Abdel-Shafy et al., 2009; Godara et al., 2014; Singh et al., 2014).

2.2 Patentometry

The patentometry enables the analysis of large volumes of information and the creation of a useful outcome for companies. Is a tool that provides greater technological orientation, and whose versatility has allowed its use to raise the state of art of variables that can illustrate the behavior of sciences in certain sectors (Romero and Weffer, 2010). In relation to the patentometry, the meaning of this notion is twofold. On the one hand, scores of patents and patent citations are used as indicators. On the other hand, patent-based indicators are used to show the production of technology and innovative activities (Sung et al., 2014).

Patents are evaluated as an index of both industrial development and as countries research, composed of relevant indicators that assess the country's capacity to transform scientific knowledge into technological innovations or products (Pavanelli and Oliveira, 2012). The analysis of patents encourage the development of several studies, both in the academic sector, research, business or industry. Within which are: identify partners; technological trends and obtainable; understand the stage of technology; protect the results in the research and development of the organization and/or of the country; seek solutions to innovative and technological problems; develop technological and business profiles; support and guide P&D programs; etc. (Sánchez, et al., 2007).

As Valdes et al. (2003) the patent documents are one of the most complete, accessible, reliable and up-to-date technological information sources covering a large number of sectors.

According to Leydesdorf (2001), the patent may be used to demonstrate the targeting and technological trends of industry sectors and the economy as a tool for analysis of potential markets, technological trends and the market and competition movements. The use of information contained in patent documents also allows you to identify relevant technologies, assist in the choice of potential partners, showing niche markets, incremental and radical innovation.

III. MATERIAL AND METHOD

For the construction of this analysis a methodological approach was adopted, which is characterized as descriptive and exploratory, with a quantitative approach and makes use of patentometric techniques. The sources of information used for the recovery of patents related to the control of *Boophilus Microplus* tick, were to Espacenet databases and Derwent Innovations Index from the Capes Portal of journals on day March 26 of 2018.

To carry out the searches, the terms "*Boophilus Microplus* and Control", "*Boophilus Microplus*" and "*Boophilus Microplus* and control and method"were used in the fields of the database Espacenet ("title" and "title and summary") and for the database Derwent Innovations Index ("title" and "topic"). The recovered patents has been consolidated and redundant patents were excluded.

First, the 245 documents were used for analysis of annual trends, and countries. Thereupon were selected the 4 International Patent Classifications (IPC) and the 15 years with the highest number of deposit, after this, the co-occurrence matrix between the classes and the inventors who have excelled was made. Soon after, the co-occurrence matrix between the IPC and year was made. The diagram of the countries and inventors was used to verify the collaboration in the development of technologies. The patemt depositors were selected by countries to check their profile to make the correlation between inventors; the chosen ones were those who obtained the 10 highest correlations.

During this research, it was used: - deposit period: date that the patent was deposited; - country: name of the country or Regional or International Organization that published the patent document; - holder: author of the invention will be ensured the right to obtain the patent that ensures the property; - depositors: any person or

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entity, that has legitimacy to obtain the patent (who applied for the patent); - International Classification: is the international rating system, created from the Strasbourg Agreement (1971), whose technology areas are divided in classes A to H. In each class, there are classes, major groups and groups, through a hierarchical system (Macedo, 2000).

The data were analyzed by using Tech Mining methodology (import data, clean data, analyze data, visualize data plots) by means the software Vantage Point ®, which is an important mining and analysis tool that allows exploration and treatment of large amount of scientific and technological information. The documents are processed with advanced bibliometric techniques and that allows to view the data in different ways through grouping of countries, authors, institutions, among others (Vantage Point ®, 2012).

IV. RESULTS AND DISCUSSION

The Table 1 presents the number of documents recovered from searches on patents using the keywords defined in the methodology.

Table.1: Number of patents found in databases

Database	Keywords	Title	Title and summary	Result
Espacenet	Boophilus Microplus and Control	1	6	7
	Boophilus Microplus	5	32	37
	Boophilus Microplus and control and method	0	0	0
Derwent Innovations Index	Boophilus Microplus and Control*	9	157	166
	Boophilus Microplus*	25	240	265
	Boophilus Microplus and control and method*	0	39	39
Total		40	474	514

Source: Table drafted by authors.

After patentometric search in the databases, the 514 documents identified were exported to Microsoft Excel, and later, the 260 repeated documents were deleted after the search. Out of these 254, 9 did not have the name of the inventor and were excluded from the research, therefore, 245 remained for analysis.

Figure 1 presents the annual evolution of 245 documents analyzed. With the results, it might be noted that the patents deposited on the subject come oscilating over the period since the first patent was in the year 1961. The invention comprises carbamic acid esters of general formula. Esters are prepared to induce a reaction a halogen-carbon acid ester (cyclopentyl or phenyl cyclopentenyl) with a mono- or dialkylamines, or induce a Cyclopentyl or phenyl cyclopentenyl to react with an acid halide mono-or dialkylcarbamic. Some examples describe the preparation of o-phenyl-cyclopentyl-N-metilcarbamate and o-phenyl-cyclopentenyl-N-metilcarbamate and its use with a diluent as insecticides and pesticides to plants and animals, deposited by the company Bayer AG in United Kingdom, the international classification used was C07C (acyclic compounds or carbocyclic).

It can be noted that there was an evolution in the accumulated growth for patents deposited over time, the most representative growth happened between the years of 1999 with 14 patent deposits and 2003 with 13 patent deposits, followed by the years of 2013 and 2017 with 12. Representing an increase in the interest of researchers on the theme. During this period, there was an average of 5.212 documents per year.

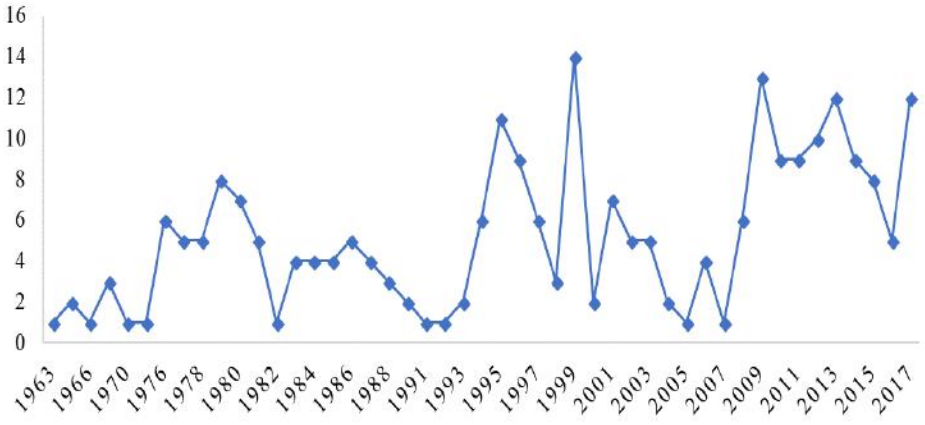

Fig.1: Number of patents deposits per year.
Source: Graphic drafted by authors

https://dx.doi.org/10.22161/ijaers.6.2.17 *ISSN: 2349-6495(P) | 2456-1908(O)*

In Figure 2, the online platform 'map in seconds' was used (CHEN, 2018), where the map of the countries of the patents found was made.

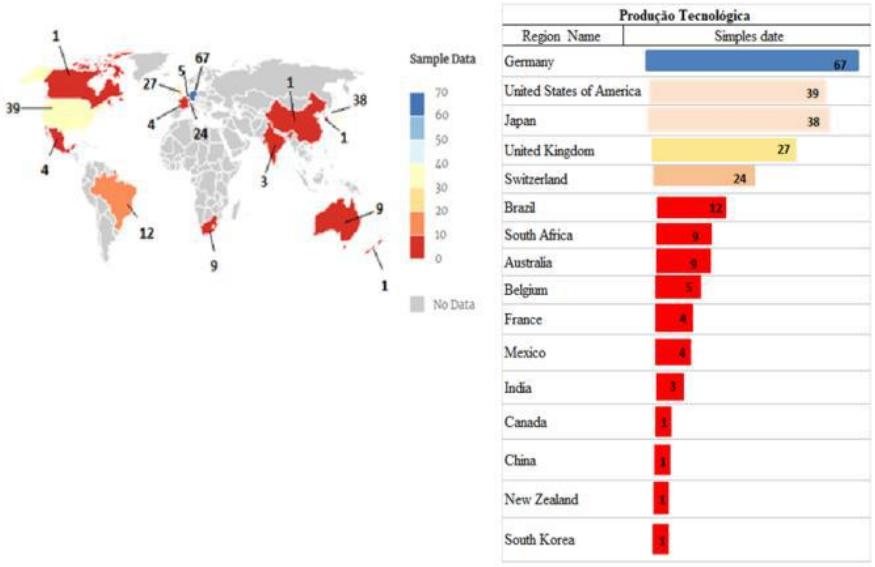

Fig. 2: Number of patents deposits per country
Source: Drafted by authors using 'map in seconds' tool.

It is observed that the most outstanding countries were: Germany with 67 patent deposits, out of these, 32 are represented by the international classification A01N (preservation of humans, animals, plants or parts of it; biocides; attractants or repellents of pests; plant growth regulators), 23 represented by C07D (heterocyclic compounds), 8 classified as C07C (acyclic compounds or carbocyclic), 2 as A61K (preparations for medical, dental or hygienic purposes) and 2 as CO7K (peptides).

Out of the 39 patents filed in the United States of America, 31 are classified as A01N; of the 38 patents deposited in Japan, 32 represents the class A01N; in the United Kingdom, from 27 deposits, 19 are represented by the subclass A01N; in Switzerland, from the 24 deposits, 19 are represented by A07N. In Brazil, it was found 12 patent deposits, being 6 represented by the classification A61K and 4 by A01N.

It is observed in Figure 3, the distribution of IPC per year, where were selected 15 years and the 4 classes that have stood out. The most representative class is represented in A01N, other classes that we can highlight are the A61K, C07C and C07D.

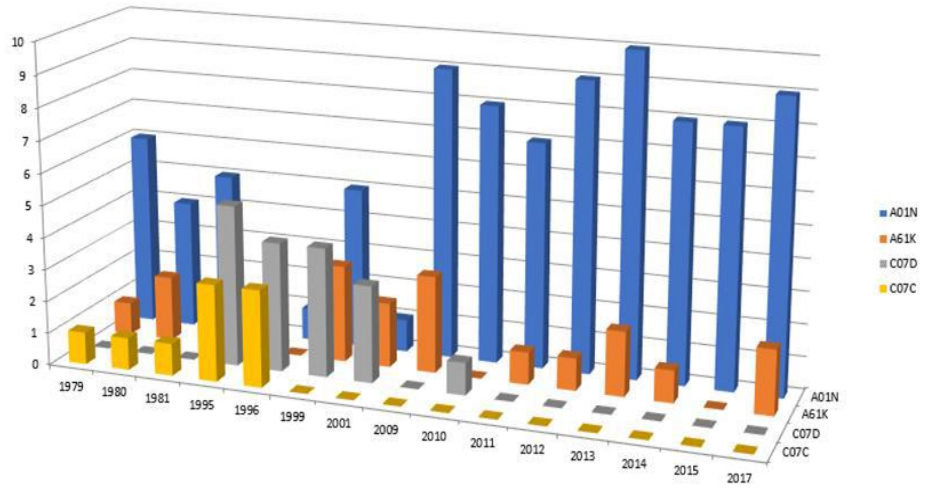

Fig. 3: International classification per year.
Source: Graphic drafted by the authors.

It is observed that the patents are most often classified in section A, which refers to human needs, followed by section C, chemistry and metallurgy.

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In table 2, the 4 classes that have stood out of 245 patents and their descriptions are represented, resulting in 234 patents for analysis.

Table 2: Description of the classes of the IPC

IPC Classes	Description	Total
A01N	A01N - Preservation of humans, animals, plants or parts of it; biocides; Attractants or repellents of pests; plant growth regulators	141
A61K	A61K - Preparations for medical, dental or hygienic purposes.	36
C07D	Heterocyclic compounds	36
C07C	Acyclic compounds or carbocyclic.	21
Total		234

Source: Drafted by the authors.

It can be observed that out of the main IPC, 60% are represented by code A01N- Preservation of humans, animal, plants or parts of it; biocides; attractants or repellents of pest; plant growth regulators.

In table 3 a more specific analysis of the description area was made, describing the 141 documents found in classes A01N, including 23 patents deposits that did not have a sub-group.

Table.3: Description of the subclass A01N of IPC

IPC Class	Subgroup	Description	Quantity
A01N	A01N	Preservation of humans, animals, plants or parts of it; biocides; attractants or repellents of pests; plant growth regulators	23
	A01N 25	Biocides, repellants or attractors of pests, or plant growth regulators, characterized by their forms, or by their non-active ingredients or by their methods of application, for example, seed treatment or sequential application; (apparatus for the destruction of noxious animals or noxious plants)	7
	A01N 27	Biocides, repellants or attractors of pests, or plant growth regulators containing hydrocarbonates	1
	A01N 29	Biocides, repellants or attractors of pests, or plant growth regulators containing halogenated hydrocarbonates	3
	A01N 31	Biocides, repellants or attractors of pests, or plant growth regulators containing organic compounds of oxygen or sulfur	6
	A01N 33	Biocides, repellants or attractors of pests, or plant growth regulators of nitrogen green plants	1
	A01N 35	Biocides, repellants or attractors of pests or plant growth regulators based in a halogen, e.g., radical aldehyde.	3
	A01N 37	Biocides, repellants or attractors of pests, or plant growth regulators of plants that is related to the carbon atom, 3 times per heteroatom and up to 2 connections with a halogen, e.g. carboxylic cyclopropane fruits	10
	A01N 43	Biocides, repellants or attractors of pests, or regulators of the beginning of set of heterogenic plants	70
	A01N 47	Biocides, repellants or attractors of pests, or regulators of the carbon atom without bond to a nitrogen atom	5
	A01N 53	Biocides, repellants or attractors of pests, or regulators of the life level of particular carboxylic cyclopropane or results of these	7
	A01N 57	Biocides, repellants or attractors of pests or regulators of plants market associated with the organic ingredients of phosphor.	6
	A01N 65	Biocides, repellants or attractors of pests, or regulators of growth of material collected from algae, lichens, bryophytes, plants or fungi multicellular or associated models.	3
Total			**141**

Source: Drafted by the authors.

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It is observed that the Group A01N 43 - Biocides, repellants or attractants of pest or regulators from the beginning of the set of heterogeneous plants was what came of the 141 A01N classes.

In Figure 4, we see the matrix of international patent classification (IPC) for allowing inventors to analyze their connection with the tech sector. The yellow node represents the IPC and inventors by the blue node, the 4 highlighted IPCs and the 15 inventors with largest number of deposits were used. The amount of each patent inventor is represented by the line width.

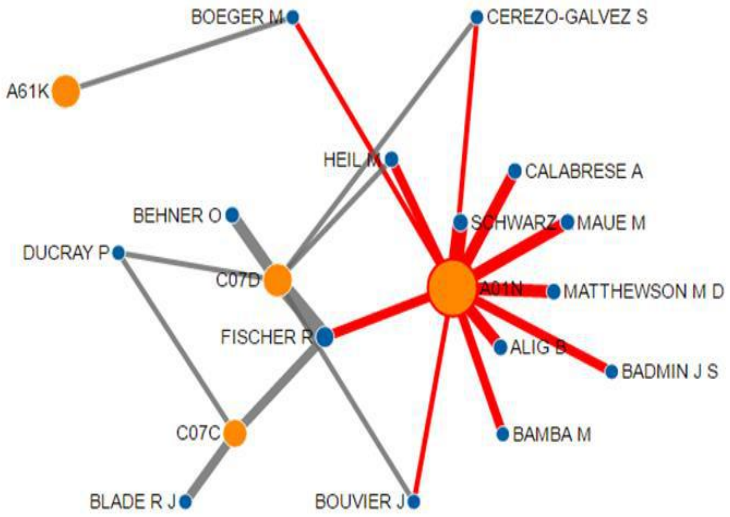

Fig. 4: Matrix of occurrence of the international classification of patents for inventors.
Source: Drafted by the authors using the software Vantage Point®.

In this case, we see that from the 15 inventors, 12 are linked to the subclass A01N (preservation of humans, animals, plants or parts of it; biocides; repellents or attractants of pest; plant growth regulators).

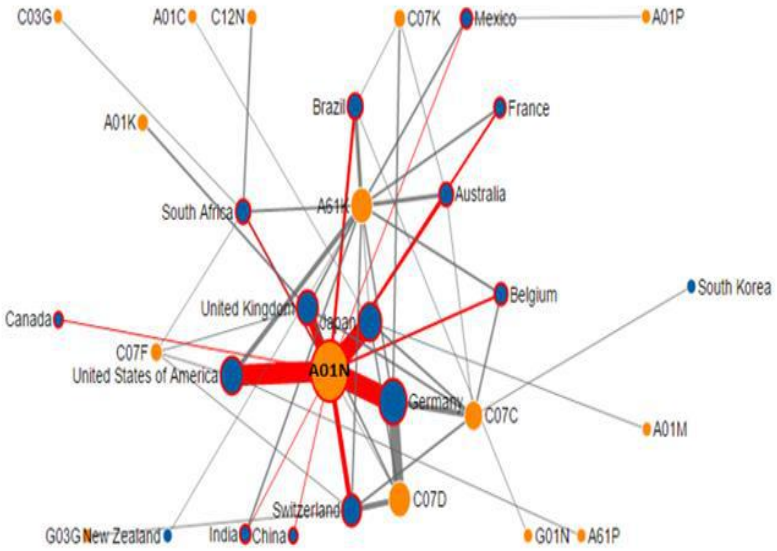

Fig. 5: Matrix of occurrence of the international classification of patents by country.
Source: Image drafted by the authors using the software Vantage Point®.

Note in Figure 5 the matrix between the 15 classifications used by inventors represented by the yellow nodes and the 16 countries found represented by the blue nodes. It turns out that the subclass A01N and A61K were used by several countries.

It is noticed that from the 16 countries, 14 are connected to A01N and 13 are connected to A61K, the two classes are in section A (Human Necessities) of IPC.

The diagram in Figure 6 represents the interaction between countries and inventors of 245 patents, thus allowing the identification of the network and the

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important links between these networks. The size of the circles represents the importance from the viewpoint of quantity of patents in each country and cooperation. Germany stands out with 05 inventors, Fischer has 06 patent deposits, Maue 03, Schwarz 03, Benhner 03, Cerezo 02. The thickness of the lines refers to the intensity of the link, i.e., the thicker the line, the greater the amount of patents that the country has. From this viewpoint, Germany, United States of America, Switzerland, United Kingdom, Belgium, Australia, South Africa, Mexico and Canada presents a link of less than (0.25) on inventors collaboration.

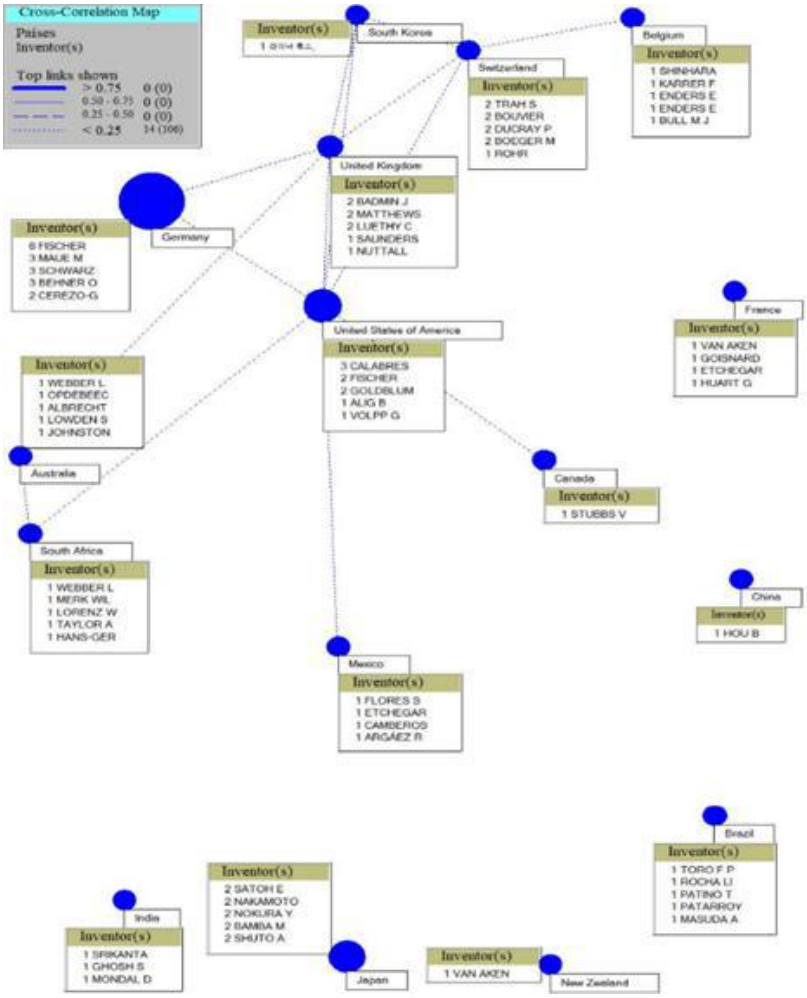

Fig. 6: Diagram of the countries and inventors and their contributions in the development of technologies.
Source: Image drafted by the authors using the software Vantage Point®.

Figure 7 shows that companies lead the ranking in deposits. We analyzed the 86 depositors found; it was checked the source of 18 countries and identified the companies, Research Institutes, independent inventors and the Universities. According to the data, the countries Australia (AU), Belgium (BE), Brazil (BR), Switzerland (CH), Germany (DE), France (FR), Great Britain (GB), India (IN), Japan (JP), South Korea (KR), United States of America (US) and Uruguay (UY) presented depositors companies. However, it is important to highlight the companies from Germany (DE), United States of America (US), United Kingdom (GB) and Japan (US) that have obtained the largest numbers of deposits.

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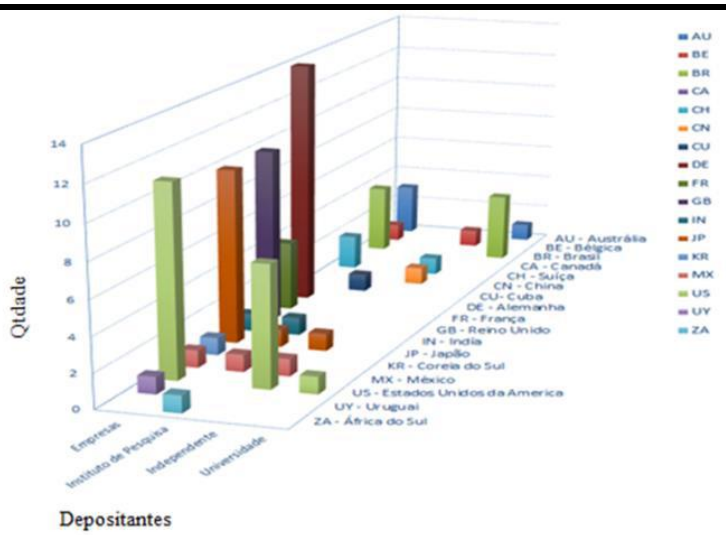

Fig. 7: Profile of depositors in several countries.

It should be noted the presence of Brazilian universities in patent deposit, although little participation, it demonstrates the importance of universities in the development of new technologies.

Table 1 shows that the 10 greatest depositors of 245 patent documents identified are made from companies. The company that comes up with the greatest number of deposits is BAYER AG, followed by BAYER CROPSCIENCE.

Table.1: Top ten depositors

Depositants	**Countries**	**Total**
BAYER AG	Germany	28
BAYER CROPSCIENCE AG	Germany	23
CIBA GEIGY AG	Germany	17
SYNGENTA PARTICIPATIONS AG	Great Britain	13
SUMITOMO CHEM CO LTD	Japan	11
NISSAN CHEM IND LTD	Japan	8
NOVARTIS AG	Switzerland	8
ICI AUSTRALIA LTD	USA	7
WELLCOME FOUND LTD	Germany	6
FARBENFAB BAYER AG	Germany	5

Source: Table drafted by the authors.

Bayer is a global company that operates in the areas of health and Agriculture (BAYER, 2015). Bayer CropScience is the Division of the company specialized in agriculture, being the third largest company of innovative agricultural commodities in the world (CROPSCIENCE, 2018).

In table 2, it was verified the eight greatest depositors of patents by profile, showing the highlight of records between companies and universities and independent inventors of 141 patent documents A01N class, listed in Table 2.

Table.2 - Eight major depositors of patents by profile.

Empresas	**Nº**	**Universidades e Institutos de Pesquisas**	**Nº**	**Inventores Independentes**	**Nº**
Bayer Cropscience Ag	23	Indian Council Agric Res	1	Bretschneider N T	2
Syngenta Participations Ag	13	Kitasato Inst	1	Mizuno H	2
Syngenta Crop Protection Inc	9	Sagami Chem Res Cent	1	Nokura Y	2
Bayer Ag	8	Univ Federal Juiz De Fora	1	Shimizu C	2

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Sumitomo Chem Co Ltd	8	Univ Queensland	1	Angst M	1
Bayer Intellectual Property Gmbh	7	Univ Sao Paulo USP	1	Boeger F	1
Ici Australia Ltd	7	Us Sec Of Agric	1	Boeckh A	1
Merial Ltd	7			Boeger F	1

Source: Table drafted by the authors.

Note that the Bayer Ag showed only 8 patent documents with this international patent classification A01N.

On a thorough search, it is verified that the publications are for combining these data to A01N class, combining with the fact that 82.9% of deposits are made by companies, 3.54% from Universities and Research Institutes, 2.8% by independent inventors and 10.6% are from joint holders.

It should be noted in table 3 the total profile of depositors found on the 141 patent documents.

Table.3-Profile of depositors of patents by profile

Companies	Universities and Research Institutes	Independent Inventors	Joint holders
117	5	4	15

Source: Table drafted by the authors.

In the academic sphere, regarding independent inventors, the proportion of patent applications is quite small, as demonstrated by the information presented in table 3.

One can understand that it is the industry that is encouraging this type of technological innovation.

V. CONCLUSION

In General, the control of *Boophilus Microplus* tick remains an important area of research, since it was reported a large resistance to chemicals. This article proposes to assess the technological productions, through the related patentometry on the subject. With the results obtained in the research, it was found a higher number of deposits from 1999 with 14 deposits, having a growing number in 2003 with 13 documents, followed by the year 2013 and 2017 with 12 patents deposited this result indicates a growing trend showing a great interest in the area.

The leading country on this type of research was Germany with 67 patent deposits, followed by the United States of America, Japan, United Kingdom, Switzerland and Brazil, with an underrepresented number of patent applications compared to other countries. The international classification by year is represented by A01N (preservation of humans, animals, plants or parts of it; biocides; Attractants or repellents of pests; plant growth regulators). It was noted that the network of collaboration among countries and inventors is greater among the inventors of Germany. The company that has the greater number of deposits is the Bayer Ag and the Bayer Cropscience, the profile of deposits found were made by companies.

It is concluded that the analyzes of this research have great relevance for the control of ticks considering that technological publications are important markers of the activity of production and development of the field of knowledge. It is hoped that the results presented in this research may be useful to the researchers and that they collaborate to the extension and expansion of the patent studies on the subject, especially in the Brazilian scope of the 12 patents represents 4.89% a small number of deposits.

ACKNOWLEDGEMENTS

Thank you to the Coordination of Improvement of Higher Education Personnel (CAPES) for the funding to carry out this rese.

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