ARTIGO / ARTICLE

LATIN AMERICAN JOURNAL OF BUSINESS MANAGEMENT

APICULTURE IN RIO GRANDE DO NORTE, BRAZIL: A FOUR-YEAR FOLLOW-UP SURVEY

Dayson Castilhos[1]
Genevile Carife Bergamo[2]
Vera Lúcia Imperatriz Fonseca[3]
Valdemar Belchior Filho[4]

Abstract

Rio Grande do Norte apiculture grew 500% between 2000 and 2009, promising to be an emergent proposal for agricultural sector in semiarid region. However from 2009 to 2015, production and beekeeping income fell sharply mainly due to typical climatic conditions of semiarid region, but with greater intensity in the period; drought drastically devastated northeast Brazil between the years 2012-2015 and fall of State GDP reduced incomes of beekeepers, which caused a disincentive and led this activity to decline. In October 2012 a follow-up survey started in order to assess beekeeping sustainability as family farming in the State through its social, economic and environmental indicators, and in October 2015 survey was finished with the same respondents, enabling to drawing a profile of beekeeping in the State during that period. PSI/ER (Pressure-State-Impact/Effect-Response) matrix was used to design the questionnaire itself. 63 random samples, surveyed in 2012 and untimely replicated till 2015, were analyzed. It was found that honeybees' colonies abscond with drought and

Recebimento: 30/10/2015 - Aceite: 9/4/2016

[1] Mestre em Ambiente, Tecnologia e Sociedade pela Universidade Federal Rural do Semi-Àrido (UFERSA) e Doutorando em PPCA - DECAN - UFERSA. E-mail: dayson.castilhos@yahoo.com.br

[2] Doutorado em Agronomia (Estatística e Experimentação Agronômica) pela Universidade de São Paulo

[3] Doutorado em Ciências Biológicas (Zoologia) pela Universidade de São Paulo

[4] Economia pela Universidade Federal da Paraíba (1981). E-mail: valdemar@rn.sebrae.com.br

high temperatures; beekeeping is greatly influenced, positively and negatively, by environment and public policies, despite the efforts dedicated to apiculture in region; and that, according to respondents, beekeeping is still underdeveloped mainly due to social problems (49.9%) as low participation of women, low educational level, aging of beekeepers; economic/technological problems (30.9%) as lack of quality of bee products, diversification of production, proper management and lack of financing; and environmental problems (19.2%) as drought and high temperatures. The absence of a methodology to avoiding effects of external variables to production process at family farming level has led this activity to decline.

Keywords: Apiculture; Environment; Drought; Beekeeping income; Decline

APICULTURA NO RIO GRANDE DO NORTE, BRASIL: QUATRO ANOS DE REGISTROS E ACOMPANHAMENTO

Resumo

A apicultura norte-rio-grandense cresceu 500% entre 2000 e 2009, prometendo ser uma proposta emergente para o setor agropecuário no semiárido. Entretanto de 2009 até 2015 a produção e renda apícola caíram drasticamente principalmente devido a fatores climáticos típicos da região semiárida, porém com maior intensidade nesse período, como a drástica seca que assolou o nordeste entre os anos 2012 a 2015 e a queda do PIB do Estado, fatores que reduziram as rendas dos apicultores, o que causou um desestimulo e levou essa atividade ao declínio. Em outubro de 2012 iniciou-se uma pesquisa com o objetivo de avaliar as condições de sustentabilidade da apicultura como atividade agropecuária familiar no Estado, através dos seus indicadores sociais, econômicos e ambientais, encerrando-se em outubro de 2015, com os mesmos entrevistados, possibilitando traçar um perfil da atividade apícola no RN nesse período. Utilizou-se a matriz PEI/ER (Pressão-Estado-Impacto/Efeito-Resposta) para criação de questionário próprio. Foram entrevistados 63 apicultores escolhidos aleatoriamente em 2012 e as mesmas entrevistas foram intempestivamente replicadas até 2015. Constatou-se que os enxames de abelhas se evadem com a seca e as temperaturas altas; a atividade melífera sofre grande influência, positiva e

negativa, do meio ambiente e das políticas públicas, apesar dos esforços dedicados à apicultura na região; e que, segundo os entrevistados, a apicultura continua subdesenvolvidas principalmente devido a problemas sociais (49.9%), como a baixa participação das mulheres, o baixo nível de escolaridade, o envelhecimento dos apicultores; problemas econômicos/tecnológicos (30.9%), como falta de qualidade dos produtos apícolas, diversificação da produção, manejo adequado e falta de financiamentos; e problemas ambientais (19.2%) como a seca e as altas temperaturas. A falta de uma metodologia que evitasse os efeitos das variáveis externas ao processo produtivo ao nível de agricultura familiar levou esta atividade ao declínio.

Palavras-chave: Apicultura; Meio ambiente; Seca; Renda apícola; Declínio

Introduction

Apiculture, considered an agricultural livestock activity (BRASIL, 1990; ROCHA, 2008) is a practice in which beekeepers capture, maintain and reproduce colonies of *Apis mellifera* aiming profit, environmental benefits, welfare and recreation (MCKNIGHT, 1982). The colonies are managed and their direct and indirect products, and services are quite diversified (Table 1).

Table 1: Direct and indirect products, and services of beekeeping

Direct products	Indirect products	Services
Honey	Beekeeping industry	Pollination
Colonies	Beekeeping commerce	Education
Apitoxin	Handicrafts	Tourism
Pollen	Pharmaceutical industry	Landscaping
Wax		Research
Propolis		Rentals
Royal jelly		Extension works
Queens		

Source: WIESE, 2000; COUTO & COUTO, 2006; VILLAS-BÔAS, 2012; our insertion.

Apiculture activity in Northeast Brazil had been growing apace and the State of Rio Grande do Norte ranked a prominent position in this industry (LIRA, 2008; LIRA *et al*, 2012). According to IBGE (2010), the city of Apodi was one of the largest honey producers in Northeast Brazil. Beekeeping was encouraged in some municipalities, such as Apodi, Mossoro, Serra do Mel and Assu, becoming a source of extra income for family farming (LIRA *et al.*, 2012).

Gonçalves *et al*. (2010) described the scenario for the region as follows:

> [...] Currently, Brazilian apiculture potential is immense, despite of the fact that there is still a lot to improve. [...] Intense Africanized honeybees' production and favorable climate make beekeeping a very profitable activity and may drive the country to be one of the world's most important suppliers of the product. [...] Northeast Brazil now accounts over one third (1/3) of honey exportation [...] and is known as "The sea of honey in the country." [...] In Mossoro, RN, a cooperation project between MCT - Ministry of Science and Technology, UFERSA -

> Federal Rural University of Semi-Arid and SEBRAE/RN -Brazilian Support Service for Micro and Small Businesses created in 2007, the institution named CETAPIS - Technological Center for Apiculture and Meliponiculture of Rio Grande do Norte, where research and extension works are developed. [...] This center is now responsible for the production and selection of queen bees, printing matrices of beeswax honeycombs and analyses of honeys. [...] It represents a major effort to boost beekeeping technology in Northeast Brazil (GONÇALVES *et al.*, 2010, p. 7-15, our translation).

Presently, due to prolonged drought in the biome (MAIA-SILVA *et al.*, 2012), mismanagement, lack of public policies for the sector and fall of State GDP (IBGE, 2015), this industry has been strongly reduced, endangering the activity, the economy and the semiarid biome (MAIA, 2013; CASTILHOS, 2014).

The aim of this study was to analyze the main indicators of beekeeping as sustainable family farming in the State of Rio Grande do Norte, through data collected between October 2012 and October 2015, measuring and comparing their values and highlighting the elements that influenced beekeeping as agricultural activity in the State.

Materials and methods

In order to develop a survey that depicts the real profile of Rio Grande do Norte beekeeping, PSI/ER methodology (Pressure-State-Impact/Effect-Response) was held. This methodology was adopted by UNEP/CIAT - United Nations Environment Programme/ International Center for Tropical Agriculture (WINOGRAD *et al.*, 1996). A questionnaire was created by adapting to regional conditions, based on table proposed by Oliveira *et al.* (2007), wherein apicultural indicators are distributed within the matrix PSI/ER (Table 2). In order to accomplish this work, only highlighted indicators were evaluated.

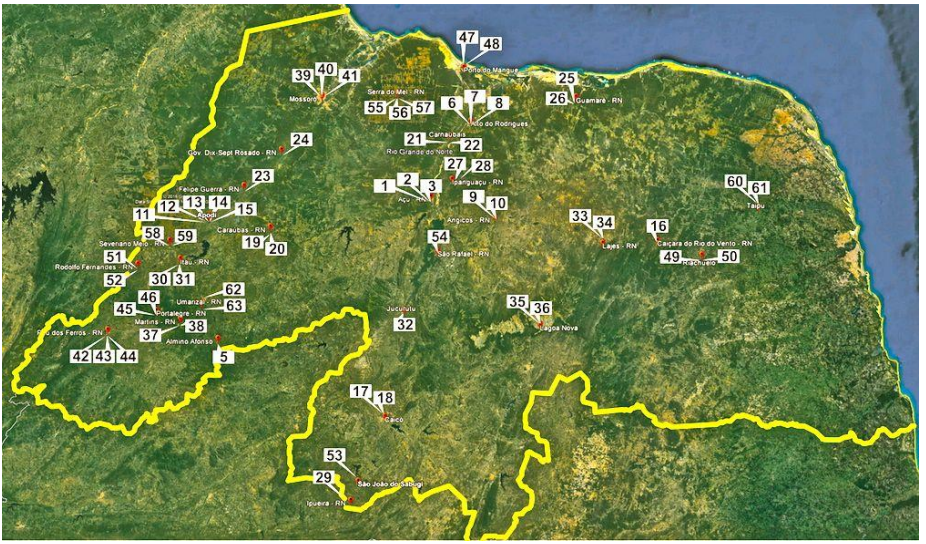
Table 2: Sustainability Assessment Indicators for Apicultural Agroecosystems in the matrix PSI/ER, adapted to biome characteristics of Rio Grande do Norte State, Brazil

Indicators of Pressure (P)	Indicators of State (S)	Indicators of Impact/Effect (I/E)	Indicators of Response (R)
Honeybees' pasture (biome characteristics)	Producer profile (age, education, gender)	Colonies losses (# colonies lost/season)	Capacitation (# training courses)
Products diversity (#)	Product cost (R$)		Technical support (# visits)
Market price (R$)	Colonies capacity (# colonies/season)	Production (Kg)	Financing (R$)
Production potential (Kg/year)	Source (# apiaries)	Packing types (#)	Income (sales) (R$)
Local consumption (Kg/year)	Daily consumption (g)	Organizations (# cooperatives and associations)	Product price (R$)
	Production modernization (R$)	Constraints	Production quality (inspections)
	Training courses (hours)		Production flow (Kg/year)

Source: OLIVEIRA *et al.*, 2007.

A survey was conducted among the same beekeepers in 2012, 2014 and 2015, always in October, and indicators were recorded in spreadsheets. 63 interviews were validated for statistical analyses (Figure 1). 9 indicators were analyzed (Table 2). Other important indicators for this study were also recorded untimely, as rainfall, maximum number of colonies per beekeeper per season (colonies capacity), absconding peaks and colonies returning. For data analyses, normality tests were applied. For qualitative data, a table was created and results were compared to pertinent updated publications. Friedman ANOVA was applied to quantitative data, with 5.0% of significance level (SIEGEL & CASTELLAN, 2006; AYRES, 2010). R Statistical Software (2014) was used for computation analyses. Pareto Diagram and SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats) tools were also applied to the surveyed data.

Figure 1: Distribution of surveyed locations on the State of Rio Grande do Norte



Source: Google Maps, 2016; our insertion.

Results and discussion

According to indicators selected in Table 2, four categorical variables were analyzed in Table 3 and results were compared to recent pertinent publications. Constraints were analyzed separately in Pareto Diagram and SWOT Analysis.

Table 3: Categorical variables table

Categorical Variables	N (%)
Honeybees' Pasture	
Semiarid	50 (79.3)
Transition	5 (7.9)
Anthropic Vegetation	4 (6.4)
Mangrove	2 (3.2)
Coast	2 (3.2)
Products Diversity	
Honey	63 (100.0)
Apitoxin	6 (9.5)
Pollen	2 (3.2)
Propolis	2 (3.2)
Wax	63 (100.0)
Royal jelly	0 (0.0)
Queen bees	0 (0.0)
Colonies	63 (100.0)
Pollination	8 (12.7)
Trading	7 (11.1)
Production Quality	
N/C	46 (73.0)
SIM	1 (1.6)
SIE	14 (22.2)
SIF	2 (3.2)
Producer Profile	
Gender	
Male	59 (93.7)
Female	4 (6.3)
Education	
Illiterate	2 (3.2)
Literate	28 (44.4)
Elementary	15 (23.8)
High School	13 (20.6)
College	5 (8.0)
Age Group	
20-29	4 (6.3)
30-39	15 (23.8)
40-49	19 (30.2)
50-59	16 (25,4)
> 60	9 (14.3)

N/C = Not Certified; SIM = Municipal Inspection Stamp; SIE = State Inspection Stamp; SIF = Federal Inspection Stamp.

Honeybees' Pasture showed that 79.3% of the total beekeepers have their fixed apiaries in semiarid region, where environmental conditions are critical. Moraes & Moura (2014), mapped semiarid in Rio Grande do Norte as 80.0% of its surface, Atlantic Forest as 6.0%, and mangrove as 2.4%. The remaining 11.6%, not related, can be attributed to coast, anthropic vegetation and transition zone.

On Products Diversity, it was reported that all respondents intend to commercialize honey, exchange raw wax for molded wax, and at last sell colonies; 9.5% collect apitoxin and keep in freezers waiting for commercialization; 3.2% collect pollen and 3.2% collect propolis for instant commercialization; 12.7% rent their beehives for melon pollination, without warranties that they will receive their colonies back at the end of the harvest due to pesticides contamination (SILVA *et al.*, 2015); and 11.1% of the beekeepers trade honey inside and outside the State, in order to keep clients supplied. Finally, production and commercialization of queen bees and royal jelly were not reported.

Production Quality was analyzed according to beekeepers acquisition of their Government Quality Certificates. It was observed that the great majority have no quality certificate at all; only one beekeeper has local certificate, 14 have state certificate available from beekeeping associations or cooperatives, and 2 have national certificate. Sebrae (2016), confirmed total numbers of certificates registered in Rio Grande do Norte as 1 local, 14 regional and 3 national.

As a complement of qualitative variables analyses, three characteristics of producer's profile were computed. About gender it was reported 93.7% male beekeepers against 6.3% female. Cruz *et al*. (2012), found for Rio Grande do Norte's family farming, 89.0% male and 11.0% female. Maia (2013), found for Rio Grande do Norte beekeeping, 94.7% male and 5.3% female; and finally, Castilhos (2014), found 93.0% male and 7.0% female. These results confirm that beekeeping, as part of state family farming, is predominantly a male activity. Actions may be taken to increase female participation in beekeeping activity.

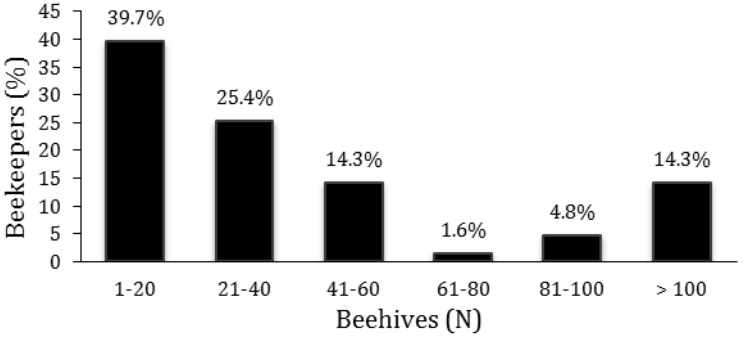
Education showed 71.4% beekeepers with low-level or no education, in accordance with Silva & Silva (2007), Maia (2013) and Castilhos (2014). Big difference was noted on beekeepers college education, which reported 8.0% of university graduation.

Finally according to age groups, Cruz *et al*. (2012), Maia (2013), and Castilhos (2014), found beekeepers ages distributed around 45 years old, as well.

For quantitative analyses, four indicators were selected: Colonies Capacity, Colonies Losses, Production and Income. Shapiro-Wilk normality test was applied to all numeric data, which showed non-normal distributions ($p<0.0001$).

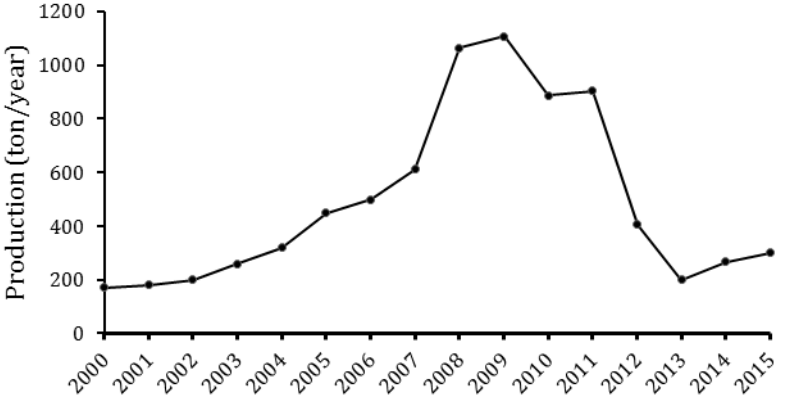
Among 63 beekeepers interviewed, most of them have small amounts of *Apis mellifera* hives. In Chart 1, note that beekeeping shows higher concentration (65.1%) in small producers, from one to forty hives.

Chart 1: Percentage of beekeepers related to their number of hives in January 2012, considered optimum moment for the season.



Beekeeping in Rio Grande do Norte, by the end of 2000's, had shown accelerated growth. Lira (2008) predicted an exponential development and the State vocation for products exportation. However, the long drought started after 2009 drove the activity to production decline, and in 2013, took it back to the levels of early 2000's. In 2014 and 2015 these levels remained low (Chart 2).

Chart 2: Beekeeping production in RN from 2000 to 2015



Source: IBGE 2010, 2014; IDEMA, 2014; SEBRAE/RN, 2016.

Due to initial premises of non-parametric data, 3 related samples in time, and same size, the best probability test to be applied is non-parametric Friedman ANOVA Test (SIEGEL & CASTELLAN, 2006; AYRES, 2010). Although there is not evidence of differences in number of beehives

according to Friedman ANOVA (X^2_r = 1.52; p = 0,4677) (Chart 3), it was observed statistical differences in production (X^2_r = 9.51; p = 0.0086) (Chart 4), and income (X^2_r = 39.61; p < 0.0001) (Chart 5), when compared themselves, year by year. That may be possible due to lack of resources and technical support, plus harsh environmental conditions at the time of survey.

Chart 3: Beehives evolution along follow-up years

- = Median; o = outlier; * = extreme.

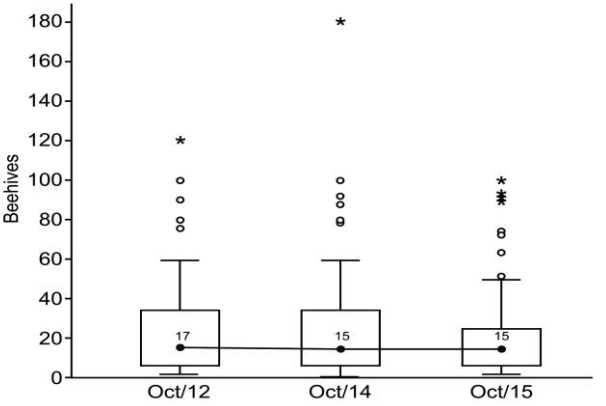


Chart 4: Beekeeping production along follow-up years

- = Median; o = outlier; * = extreme.

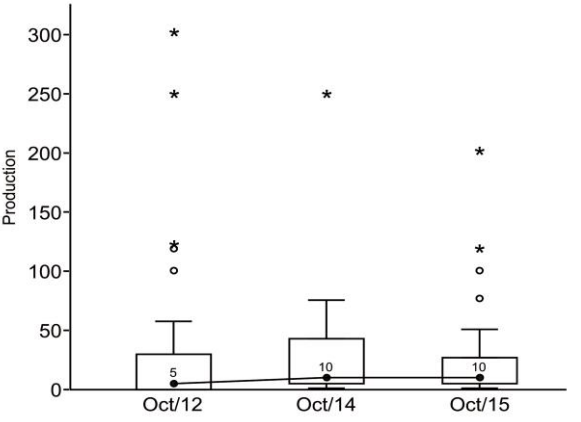
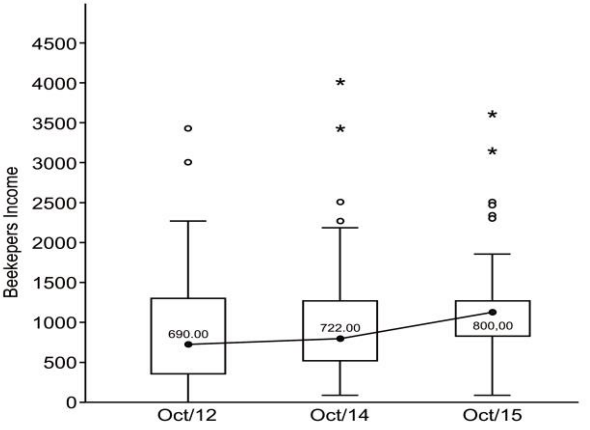


Chart 5: Beekeepers income along follow-up years

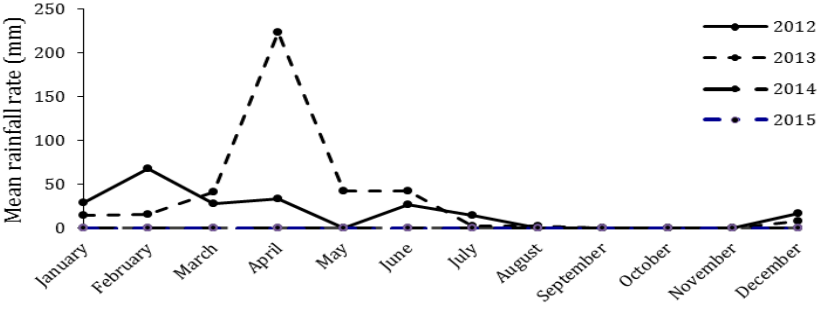
- = Median; o = outlier; * = extreme.



Despite institutions' efforts like CETAPIS - Technological Center of Apiculture and Meliponiculture, RN; SEBRAE/RN - Brazilian Support Service for Micro and Small Businesses; and UFERSA - Federal Rural University of Semi-Arid to providing training, research, extension works and development projects to the State beekeeping, the main problem is still untouched, for drought was the variable that most harmed this activity, and the main reason of respondents complaints.

Presently, apiculture passes through a period of decline in region. Prolonged drought and short rainy season (Chart 5) caused many difficulties, especially for family farmers.

Chart 5: Monthly rainfall rates in western RN from 2012 to 2015



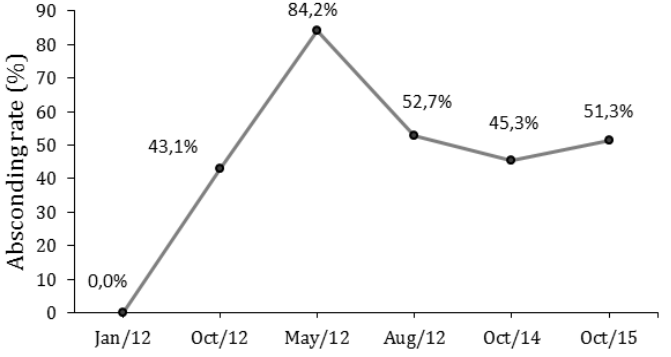
Source: UFERSA, 2016.

Absconding, due to excessive heat inside beehives, with temperatures over 41°C (ALMEIDA, 2008) provided, in May 2013, the peak of 84.2% in *Apis mellifera* colony loss rate. However, between May and August 2013, *Apis mellifera* reduced absconding (52.7%) returning to abandoned hives. In less than three months, it was observed not only an *Apis* behavior changing related to non-absconding, but a high returning rate as well. It was noticed a returning of 3 times the number of remaining colonies, from 495 to 1,487, recovering 47.3% of the maximum number of *Apis* colonies before drought, January 2012, when 3,142 beehives were reported populated.

In the accounting for absconding, stay and return, when climate got worse, inevitably new bloom has disappeared and *Apis mellifera* abandoned their hives faster (Chart 6).

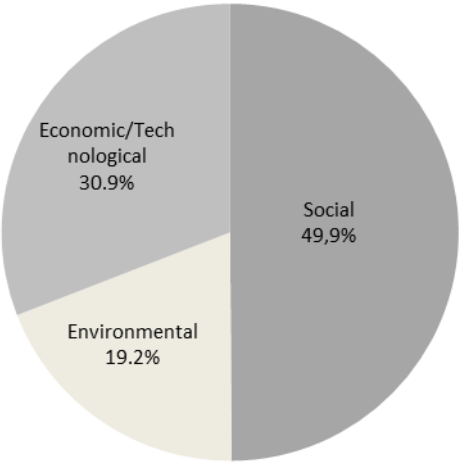
Thus, despite the fact that absconding rate (84.2%), observed in May 2013, had been extremely high, this datum can be interpreted as a better *Apis mellifera* adaptability or resistance to semiarid climate, if we consider that honeybees also returned very quickly when weather conditions improved.

Chart 6: Absconding rates of honeybees from 2012 to 2015



Constraints reported by respondents were classified as environmental, economic/technological and social. For those constraints considered as having equally social and economic/technological root-causes, Pareto Diagram and SWOT Analysis defined the root-causes, considering their prevailing characteristic sources (Chart 7).

Chart 7: Constraints root-causes (%) reported by respondents in October 2012

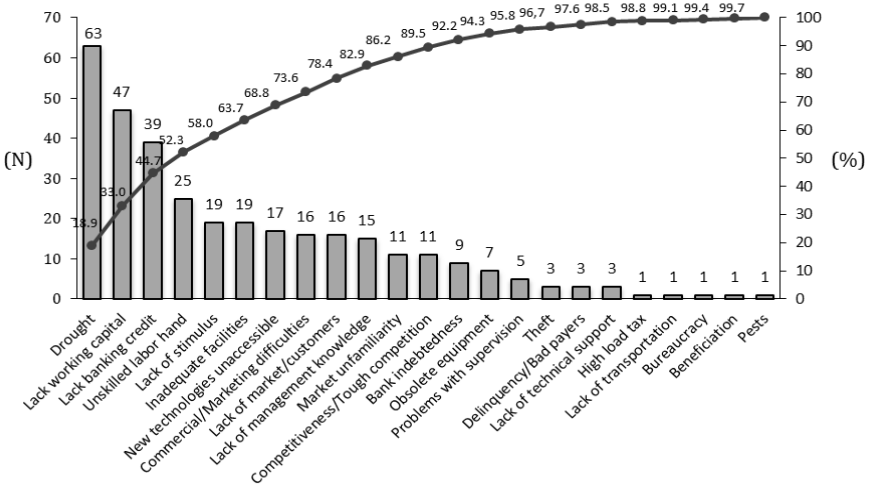


Firstly, social constraints were reported (49.9%) as the most neglected by government and public institutions. These constraints need new strategies that can reduce the harmful effects of increasing abandonment of family farming, which is the base of Rio Grande do Norte majority population.

Economic/technological constraints (30.9%) were appointed as second in respondents' complaints. Lack of training, technical support and access to technology maximize the effects of environmental and social issues.

Thirdly, environmental constraints were reported. Drought (18.9%) was a unanimous problem among respondents and it was mentioned as the biggest obstacle to small producers development, affecting family farming. Pareto Diagram recommends initially to address critical constraints (Chart 8), which are the first 80.0% of the cumulative curve that covers drought, followed by social and economic/technological problems.

Chart 8: Pareto Diagram with reported constraints of respondents



Based on variables' analyses and Chart 8 reports, a SWOT Analysis was accomplished (HUMPHREY, 2005), driving to decision-making that will bring higher yields to beekeeping as an integral part of family farming (Table 4).

Table 4: SWOT Analysis for Apiculture in the State of Rio Grande do Norte, Brazil

Factors	**Apiculture**
Strengths	Higher production Products regulated by MAPA Easy collection Easy colonies reproduction Easy swarm capture Easy return to abandoned hive
Opportunities	Improve management Add value to products Add value to services Train technicians, multipliers and beekeepers Pollination services sales Rearing and selection of queens
Weaknesses	Higher colonies absconding with drought Possible risk to producer Handling problems Low market prices of honeybees products and services Lack of production, improvement and queen selection center Lack of mechanization Wrong equipment Poor honeybees' products quality
Threats	Drought Over-heat inside hives Mass absconding Colony Collapse Disorder (CCD) Pesticides Pathogens Mismanagement

MAPA - Ministério da Agricultura, Pecuária e Abastecimento

SWOT Analysis above, shows that Rio Grande do Norte apiculture lacks a "Strategic Planning", robust and structured at institutional level, in order to deliver improved conditions to apicultural activity, and an "Annual Action Plan" for each producer, enabling them to reaching the ultimate goal of the production process, the financial profit. Without that income, small farmers migrate to another activity that offers them immediate cash return, forcing them to leaving previous activity (NASCIMENTO, 2004; NIEDERLE & SCHNEIDER, 2007).

Regardless values of apicultural products and services, incomes statements, Pareto Diagram (Chart 8) and drought (Chart 5), which have been harmful for beekeeping (Chart 6), it was observed that starting an apiary with 20 hives of well populated Africanized honeybees, yields can exceed 25.0 Kg/hive/flowering, so, an estimated production of 500.0 Kg per 20 hives per season, considering a crop without external variables effects, like drought, occurred in recent years in the State of Rio Grande do Norte, Brazil (CASTILHOS, 2014).

Conclusions

It was concluded, according to sample analyses, that despite the fact that agricultural income increased due to diversification of production and urban or rural pluriactivity, beekeeping income had been very low during followed-up years. The number of beehives along the surveyed years didn't show significant statistical differences, production kept low and income had been observed statistical differences probably due to economy inflation.

Prolonged drought was responsible for fails in management of Africanized honeybees and honey production didn't increase significantly in the State (Chart 2). The short rainy season, in April and May 2013 (223.0 mm) was not enough for beekeepers to strengthening the returning colonies after the great absconding of 2012/2013.

The resumption of drought provided low production, causing loss of net income to beekeepers. It can be stated that increment on beekeeping income during the survey period, statistically confirmed, was not related to the number of beehives, or honey production, but related to rise of products' prices.

Based on results obtained between 2012 and 2015 we conclude that honeybees swarms abscond with drought and high temperatures; honeybee activity is greatly influenced, positively and negatively, by environment and public policies, despite the efforts dedicated to beekeeping in the region; and according to respondents, beekeeping remains underdeveloped, addressing 49.9% of the problems to social assistance, 30.9% to economic/technological assistance and 19.2% to environmental problems such as climate and frequent drought in the northeast semiarid.

This conclusion indicates that a "Strategic Planning" must be designed to encourage beekeepers to continue in apiculture. Family farming sustainability of beekeepers in Rio Grande do Norte still remains critical.

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