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Original Article

Do arthropods and diseases affect the production of fruits on *Caryocar brasiliense* Camb. (Malpighiales: Caryocaraceae)?

Artrópodes e doenças afetam a produção de frutos em *Caryocar brasiliense* Camb. (Malpighiales: Caryocaraceae)?

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Abstract

Frequencies, magnitudes, and distributions of occurrence can affect the events. The problem can be worse or the solution better if greater frequencies and magnitudes are presented with aggregated distribution in the production system. Indices, hence, are used to assist in decision-making on certain issues. The system formed by *Caryocar brasiliense* Camb. (Malpighiales: Caryocaraceae), a typical and economically important Brazilian Cerrado tree species, and its several arthropods are adequate to evaluate a new index. This study aimed to test an index to identify the loss and solution sources and their importance in the system's loss or income gain. The index is: Percentage of Importance Indice $(\%\ I.I.) = \left[\left(ks_1 \times c_1 \times ds_1\right) / \Sigma\ \left(ks_1 \times c_1 \times ds_1\right) + \left(ks_2 \times c_2 \times ds_2\right) + \left(ks_n \times c_n \times ds_n\right)\right]\ x\ 100$. The $\%\ I.I.$ separated the loss sources [e.g., *Edessa rufomarginata* De Geer, 1773 (Hemiptera: Pentatomidae) on fruits = 41.90%)] on the percentage of reduction of fruit production (e.g., 0.13%), calculated the attention level (e.g., 0.10/fruit), with a total lost production of 1.35% (≈ 307 total lost fruits). The *% I.I.* also separated the solution sources [e.g., *Zelus armillatus* (Lep. and Servi., 1825) (Hemiptera: Reduviidae) = 55.48%), the non-attention level (e.g., *Z. armillatus*: 0.394 for *E. rufomarginata* on fruit), with total income gain of 0.56% (≈ 128 total saved fruits) on the natural system (e.g., *C. brasiliense* trees). This index can calculate losses or the effectiveness of the solutions monetarily. Here I test the *% I.I.*, an index that can detect the key loss and solution sources on the system, which can be applied in some knowledge areas.

Keywords: abundance, aggregation, agriculture, chi-squared test, constancy, frequency, natural system.

Resumo

Frequências, magnitudes e distribuição de ocorrência pode afetar os eventos. O problema pode ser pior ou a solução melhor se maiores frequências e magnitudes forem apresentadas com distribuição agregada no sistema de produção. Índices, então, são usados para assistir na decisão de certas questões. O sistema formado pelo *Caryocar brasiliense* Camb. (Malpighiales: Caryocaraceae), uma espécie arbórea típica e economicamente importante do Cerrado brasileiro, e seus diversos artrópodes são adequados para avaliar um novo índice. A motivação deste trabalho foi testar um índice capaz de identificar as fontes de perda e de soluções, e suas importâncias em termos de perdas ou ganhos no sistema. O índice é: percentagem de importância $(\%\ I.I.) = \left[\left(ks_1 \times c_1 \times ds_1\right) / \Sigma\ \left(ks_1 \times c_1 \times ds_1\right) + \left(ks_2 \times c_2 \times ds_2\right) + \left(ks_n \times c_n \times ds_n\right)\right]\ x\ 100$. O $\%\ I.I.$ separou as fontes de perda [ex., *Edessa rufomarginata* De Geer, 1773 (Hemiptera: Pentatomidae) em frutos = 41,90%)] na percentagem de redução na produção de frutos (ex., 0,13%), calculando o nível de atenção (ex., 0,10/fruto), com um total de perda de produção de 1,35% (≈ 307 frutos totais perdidos). O *% I.I.* também separou as fontes de solução [ex., *Zelus armillatus* (Lep. and Servi., 1825) (Hemiptera: Reduviidae) = 55,48%)], o nível de não atenção (ex., *Z. armillatus*: 0,394 para *E. rufomarginata* em fruto), com total de ganho de 0,56% (≈ 128 total de frutos salvos) no sistema natural (ex., árvores de *C. brasiliense*). Esse índice pode calcular essas perdas ou a eficácia das soluções monetariamente. Aqui eu testo o *% I.I.*, um índice capaz de detectar fatores chaves de perda e de soluções no sistema, capaz de ser aplicado em algumas áreas do conhecimento.

Palavras-chave: abundância, agregação, agricultura, teste do qui-quadrado, constância, frequência, sistema natural.

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1. Introduction

Events (e.g., agricultural pest) can have different magnitudes (numerical measurements), frequencies, and distributions (aggregate, random, or regular) of occurrence and I based on this triplet to develop a new index – Percentage of Importance Indice (*% I.I.*) (Demolin-Leite, 2021). The problem can be worse or the solution better if greater frequencies and magnitudes are presented with aggregated distribution in the production system (e.g., pests versus natural enemies) (Demolin-Leite, 2021). Hence, indices are used to help on decision-making in certain questions and, many of them, determine key-factors in an event, on the agrarian and biological areas: Crop and Ecological Life Tables (Henderson and Southwood, 2016; Silva et al., 2017), among others. Usually, these tools use abundance (magnitude) which can be analyzed by correlation, mean or t-tests, multiple or simple regression analysis, etc. (Henderson and Southwood, 2016; Silva et al., 2017; Demolin-Leite, 2021).

The Percentage of Importance Indice (*% I.I.*) is effective in identifying loss sources on the system (e.g., reduction in production) (Demolin-Leite, 2021), it is simpler than a Crop Life Table (Silva et al., 2017), but it does not replace it (Demolin-Leite, 2021). The use of *% I.I.* is for cases (e.g., natural system, Cerrado) in which it is not possible to evaluate all flowers and fruits of all plants in the experimental useful plot, identifying the factors of plant loss (Demolin-Leite, 2021), as done by Crop Life Table (Silva et al., 2017). Parameters of Life Table supply reliable information, e.g. reproductive potential and mortality factors of species (Henderson and Southwood, 2016). The *% I.I.* is, also, effective in identifying solution sources on the system (e.g., increasing production) (Demolin-Leite, 2021), similar to an Ecological Life Table (Henderson and Southwood, 2016). The *% I.I.* does not replace an Ecological Life Table (Henderson and Southwood, 2016). The use of *% I.I.* is for cases (e.g., natural system, Cerrado) in which it is not able to mark and monitor the animal (e.g., pest insects), identifying the cause of its mortality (Demolin-Leite, 2021), as done by Ecological Life Table (Henderson and Southwood, 2016). Insect pest rearing, detailed field studies, time, and researchers trained to identify and quantify the control of natural factors daily until the insect pest life cycle is complete, are the most significant steps to determine the parameters of a Life Table of pest insects (Silva et al., 2017). The *% I.I.* can be significant for preserving native areas from helping traditional communities, like the *quilombolas* (rebellious slaves refuge area in the Brazilian colonial period), indigenous, collectors (e.g., of fruits), etc., to identify the true loss sources of production in native plants. Thus, together with the help of extension researchers, they can plan the best management of these potential pests.

The system's composition with *Caryocar brasiliense* Camb. (Malpighiales: Caryocaraceae), a typical and economically important Cerrado tree species (Leite et al., 2006), and its several arthropods (e.g., herbivorous and natural enemies) in central Brazil (Leite, 2014; Leite et al., 2022) are adequate to evaluate a new index. *Caryocar brasiliense* trees, protected by Brazilian federal laws, are the primary income source of many communities (Leite et al., 2006). Hence, these trees are left in the Cerrado areas even after being converted to pasture, urban or agricultural areas, with a common scenario of isolated individual plants in the agro-urban landscape.

This study aimed to test a new index, which can determine the loss and solution sources, classifying them according to their importance in terms of loss or income gain on the system – *C. brasiliense* trees.

2. Material and methods

2.1. Percentage of Importance Indice (% I.I.)

The type of distribution (aggregated, random, or regular) of lost source (*L.S*). or solution source (*S.S.*) was defined by the Chi-square test using the BioDiversity Professional program, version 2 (Krebs, 1989). The data were subjected to simple regression analysis and their parameters were all significant ($P< 0.05$) using the statistical program System for Analysis Statistics and Genetics (SAEG, 2007), version 9.1 (Table 1). Simple equations were selected by observing the criteria: i) distribution of data in the figures (linear or quadratic response), ii) the parameters used in these regressions were the most significant ones ($P< 0.05$), iii) $P< 0.05$ and *F* of the Analysis of Variance of these regressions, and iv) the coefficient of determination of these equations (R^2). Only loss sources and solution sources with $P< 0.05$ were shown in Table 1. It is necessary knowledge of the system to select the possible loss and solution sources.

The equation of the % of Importance Indice (*% I.I.*) (Demolin-Leite, 2021) is Equation 1:

$$\% \ I.I. = \left\{ \begin{matrix} \left(ks_1 \times c_1 \times ds_1\right) / \Sigma \ \left(ks_1 \times c_1 \times ds_1\right) \ + \\ \left(ks_2 \times c_2 \times ds_2\right) \ + \ \left(ks_n \times c_n \times ds_n\right) \end{matrix} \right\} \times 100 \tag{1}$$

where,

i) *key source* (*ks*) is:

ks = reduction on production (*R.P.*)/total *n* of the *L.S.* or effectiveness of the solution (*E.S.*)/total *n* of the *S.S.*.

Where,

R.P. or *E.S.* = $R^2 \times (1 - P)$ when it is of the first degree, or *R.P.* or *E.S.* = $((R^2 \times (1 - P)) \times (\beta_2/\beta_1)$ when it is of the second degree.

Where,

R^2 = determination coefficient and *P* = significance of ANOVA, β_1 = regression coefficient, and β_2 = regression coefficient (variable^2), of the simple regression equation of the *L.S.* or *S.S.*.

When a *S.S.* acts on more than one *L.S.*, theirs *E.S.* are summed. *E.S.* or *R.P.* = 0 when *E.S.* or *R.P.* is non-significant on the *L.S.* or *R.P.*, respectively.

ii) *constancy* (*c*) is (Demolin-Leite, 2021):

c = Σ of occurrence of *L.S.* or *S.S.* on the samples.

Where,

absence = 0 or presence = 1.

iii) *distribution source* (*ds*) (Demolin-Leite, 2021) is:

ds = 1 - ***P*** of the chi-square test of *L.S.* or S.S. on the samples.

Table 1. Aggregated (Agg.), regular (Reg.), or random (Ran.) distribution (Dist.) of the loss or solution sources; and simple regression equations with their coefficients of determination (**R²**), significance (***P***) and ***F*** of the analysis of variance (Var.) (ANOVA) of reductions of total fruit production (F.P.) by phytophagous arthropods and diseases and reductions of these pests by natural enemies in branch (b.), leaf (l.), flower (f.), fruit (fr.), and/or trunk (t.) on 20 *Caryocar brasiliense* trees.

Loss sources - phytophagous arthropods and diseases	**Chi-square test**			
	Var.	**Mean**	***P***	**Dist.**
Acari: Acaridae (l.)	0.05	0.05	0.46	Ran.
Histiostomidae, *Histiostoma* sp. (l.)	282.16	21.45	0.00	Agg.
Tetranychidae, *Eutetranychus* sp. (l.)	0.45	0.15	0.00	Agg.
Tetranychus sp.1 (l.)	4.88	1.60	0.00	Agg.
Tetranychus sp.2 (l.)	2.93	1.25	0.00	Agg.
Blattodea: none identified (l.)	0.09	0.10	0.52	Ran.
Termitidae, *Constrictotermes cyphergaster* (Silvestri, 1901) (t.,b.)	8.98	2.85	0.00	Agg.
Coelomyceto, *Phomopsis* (Sacc.) Bubák (b.)	249.71	6.85	0.00	Agg.
Coleoptera: Alticidae, *Oedionychus* sp. (l.)	0.05	0.05	0.46	Ran.
Chrysomelidae, *Diabrotica speciosa* Germar, 1824 (l.)	0.05	0.05	0.46	Ran.
Curculionidae, *Naupactus* sp.1 (l.)	0.56	0.35	0.05	Ran.
Naupactus sp.1 (fr.)	123.00	10.50	0.00	Agg.
Naupactus sp.2 (l.)	0.05	0.05	0.46	Ran.
Naupactus sp.3 (l.)	3.06	0.70	0.00	Agg.
Rhinochenus stigma (L., 1758) (l.)	0.17	0.20	0.66	Ran.
Elateridae, *Apoptus* sp. (l.)	0.37	0.55	0.86	Ran.
Tenebrionidae, *Camaria* sp. (l.)	0.05	0.05	0.46	Ran.
Lepidoptera, none identified (l. miner)	109.11	20.50	0.00	Agg.
Arctiidae (l.)	0.05	0.05	0.46	Ran.
Cossidae (t.)	1.43	0.80	0.02	Agg.
Ctenuchiidae (l.)	0.09	0.10	0.52	Ran.
Nymphalidae, *Eunica bechina* Talbot, 1928 (l.)	0.09	0.10	0.52	Ran.
Oecophoridae (l.)	0.09	0.10	0.52	Ran.
Sesiidae, *Carmenta* sp. (fr.)	23.01	4.20	0.00	Agg.
Hemiptera: Aethalionidae, *Aethalium reticulatum* L., 1767(l.)	0.05	0.05	0.46	Ran.
A. reticulatum (f.)	0.80	0.20	0.00	Agg.
Aleyrodidae, *Bemisia tabaci* (Genn., 1889) (l.)	0.09	0.10	0.52	Ran.
Aphididae, *Aphis gossypii* Glover, 1877 (l.)	22.66	1.65	0.00	Agg.
Cercopidae, *Mahanarva* sp. (l.)	0.67	0.40	0.03	Ran.
Cicadellidae, *Dikrella caryocar* Coelho,Leite and Da-Silva,2014(l.)	1099.73	37.05	0.00	Agg.
Frequenamia sp. (l.)	2.57	0.60	0.00	Agg.
Aconophora sp. (l.)	3.12	0.80	0.00	Agg.
Aconophora sp. (f.)	8.62	0.90	0.00	Agg.
Aconophora sp. (fr.)	168.34	5.15	0.00	Agg.
Pentatomidae, *Edessa rufomarginata* De Geer, 1773 (l.)	5.27	2.30	0.00	Agg.
E. rufomarginata (b.)	739.57	14.90	0.00	Agg.
E. rufomarginata (fr.)	5.04	1.90	0.00	Agg.
Pseudococcidae, *Pseudococcus* sp. (l.)	15.29	1.65	0.00	Agg.
Hymenoptera none identified (l.)	8.99	2.45	0.00	Agg.
None identified (f.)	0.09	0.10	0.52	Ran.
Apidae, *Trigona spinipes* Fabr., 1793 (f.)	4.33	1.30	0.00	Agg.
Eulophidae (l.)	5.94	4.00	0.08	Ran.
Eurytomidae, *Bruchophagus* sp. (l.)	1.48	0.70	0.00	Agg.
Eurytoma sp. (l.)	87472.71	251.89	0.00	Agg.

Table 1. Continued...

Loss sources - phytophagous arthropods and diseases	Chi-square test			
	Var.	**Mean**	***P***	**Dist.**
Orthoptera: Tettigoniidae, *Oxyprora flavicornis* Redtenb, 1891 (l.)	0.05	0.05	0.46	Ran.
Solution sources - natural enemies				
Acari: Ascidae, *Proctolaelaps* sp. (l.)	82.56	2.65	0.00	Agg.
Stigmaeidae, *Agistemus* sp. (l.)	15.42	3.05	0.00	Agg.
Araneae: various species of spiders (l., f.)	2.03	1.65	0.22	Ran.
Coleoptera: Carabidae, *Calosoma* sp. (l.)	0.20	0.10	0.01	Agg.
Coccinellidae, *Neocalvia fulgurata* Mulsant, 1850 (l.)	4.30	0.75	0.00	Agg.
Diptera: Alycaulini (l.)	86.98	5.85	0.00	Agg.
Hemiptera: Geocoridae, *Epipolops* sp. (l.)	1.63	1.05	0.06	Ran.
Reduviidae, *Zelus armillatus* (Lep. and Servi., 1825) (l.)	0.64	0.70	0.56	Ran.
Hymenoptera:Aphelinidae, *Ablerus magistretti* Blanchard, 1942(l.)	263.01	14.20	0.00	Agg.
Eulophidae, *Quadrastichus* sp. (l.)	7.14	1.75	0.00	Agg.
Eurytomidae, *Sycophila* sp. (l.)	7386.04	79.60	0.00	Agg.
Formicidae, *Crematogaster* sp. (l., f., fr.)	359.00	24.45	0.00	Agg.
Pseudomyrmex termitarius (Smith, 1877) (l., fr.)	0.73	0.90	0.70	Ran.
Neuroptera, Chrysopidae, *Chrysoperla* sp. (l.)	0.24	0.15	0.05	Ran.
Thysanoptera: Phlaeothripidae, *Holopothrips* sp. (l.)	0.95	1.00	0.52	Ran.
Trybonia sp. (l.)	158.15	7.60	0.00	Agg.

Simple regression analysis	R^2	ANOVA	
		F	***P***
F.P.=757.13+150.07x*Aconophora* sp. (fr.)-2.18x*Aconophora* sp. (fr.)^2	0.46	7.15	0.0056
F.P.=1852.86-173.60x*Carmenta* sp. (fr.)	0.56	22.47	0.0002
F.P.=502.21+1605.48xCossidae (t.)-331.72xCossidae (t.)^2	0.52	9.30	0.0019
F.P.=1682.18-26.47x*E. rufomarginata* (b.)	0.49	17.23	0.0006
F.P.=2022.18-438.26x*E. rufomarginata* (fr.)	0.80	72.38	0.0000
F.P.=1474.52-35.61x*E. rufomarginata* (l.)	0.29	7.44	0.0138
F.P.=23.54+193.38x*Naupactus* sp.1(fr.)-4.10x*Naupactus* sp.1 (fr.)^2	0.90	75.78	0.0000
F.P.=30.14+8.89x*Eurytoma* sp. (l.)-0.01x*Eurytoma* sp. (l.)^2	0.88	64.78	0.0000
F.P.=1685.00-38.44x*Phomopsis* sp. (b.)	0.42	13.11	0.0020
F.P.=456.41+1071.39x*T. spinipes* (f.)-125.08x*T. spinipes* (f.)^2	0.53	9.66	0.0016
Carmenta sp.(fr.)=8.12-0.16x*Crematogaster* sp.	0.40	12.10	0.0027
E. rufomarginata (b.)=47.08-1.06x*Crematogaster* sp.	0.47	15.63	0.0009
E. rufomarginata (fr.)=4.47-0.10x*Crematogaster* sp.	0.68	37.55	0.0000
E. rufomarginata (fr.)=0.55+4.33x*P. termitarius*-1.60x*P. termitarius*^{2}	0.40	5.65	0.0131
E. rufomarginata (fr.)=3.18-1.62x*Z. armillatus*	0.32	8.53	0.0091
E. rufomarginata (l.)=21.73-0.49x*Crematogaster* sp.	0.29	7.51	0.0134
Eurytoma sp. (l.)=-7.17+3.09x*Crematogaster* sp.-0.03x*Crematogaster* sp.^{2}	0.84	45.56	0.0000
Eurytoma sp. (l.)=13.79+0.80x*Sycophila* sp.-0.003x*Sycophila* sp.^{2}	0.67	17.15	0.0001
Eurytoma sp. (l.)=-50.58+28.55x *A. magistretti*-0.23x *A. magistretti*^{2}	0.83	40.33	0.0000
Eurytoma sp. (l.)=8.12+356.49x*Epipolops* sp.-49.26x*Epipolops* sp.^{2}	0.66	16.15	0.0001
Eurytoma sp. (l.)=101.60+619.94x*Z. armillatus*-257.87x*Z. armillatus*^{2}	0.31	3.74	0.0450
Naupactus sp.1(fr.)=-8.17+1.31x*Crematogaster* sp.-0.01x*Crematogaster* sp.^{2}	0.80	34.52	0.0000
Naupactus sp.1 (fr.)=3.40+25.15x*Z. armillatus*-9.55x*Z. armillatus*^{2}	0.44	6.79	0.0068

2.2. Loss estimates and solutions effectiveness

Percentage of loss of production per loss source (*% L.P.L.S.*) is Equation 2:

$$\%\ L.P.L.S. = \left(L.P.L.S. / M.E.P.\right) \times 100. \quad (2)$$

Where,
Loss of production per loss source (*L.P.L.S.*) = total *n* of the *L.S.* x *R.P.* of the *L.S.*,
and
maximum estimated production (*M.E.P.*) = Total production (*P.*) + Σ $L.P.L.S._1$ + ...$L.P.L.S._n$.
Income gain (*I.G.*) = *L.P.L.S.* x *E.S.*
and *%I.G.* is Equation 3

$$\%I.G. = \left(I.G. / M.E.P.\right)*100 \quad (3)$$

In this case, the *E.S.* of the *S.S.* is separated per *L.S.*.

2.3. Attention and non-attention levels

Attention level (A.L.) is Equation 4

$$A.L. = \left(n\,of\ \ the\,L.S.\ per\ \ sample\ x\ 0.75\right) / \%\ L.P.L.S \quad (4)$$

Where,
n of the *L.S.* per sample = *n*/(number of trees/evaluation frequency/years/number of plant parts evaluated).
In this paper, the number of trees = 20; evaluation frequency = 12 months per year for leaves, trunks, and branches, two months for bunches of flowers per year, and three months for bunches of fruits per year; years = three; and the number of plant parts evaluated = 12 leaves, 12 bunches of flowers and/or fruits, and one trunk per tree/evaluation.
And,
0.75 = 1% of loss fruits x 0.75 (safety margin)
Non-attention level (*N.A.L.*) is Equation 5

$$N.A.L. = \left(A.L. \times 1.25\right) / E.S. \quad (5)$$

And,
1.25 = 25% plus as safety margin.

2.4. Study sites

This study was performed in Montes Claros, Minas Gerais state, Brazil, for 3 consecutive years (June 2016 through June 2019). This region has dry winters and rainy summers with an Aw: tropical savanna climate, according to Köppen. The study was developed in the *sensu stricto* Cerrado area (16º 44' 55.6" S, 43º 55' 7.3" W, at an elevation of 943 masl, with dystrophic yellow-red oxisol soil with sandy texture) which was described by Leite et al. (2006). Permission to collect arthropods in these locations/activities was granted by the landowner (Universidade Federal de Minas Gerais) and the collected arthropods are neither endangered nor protected species. Adult *C. brasiliense* trees (reproductive stage) in the Cerrado (20 trees) were ≈11.5 m height, ≈14.1 m crown width, and ≈0.31 m trunk diameter (1.5 m height).

2.5. Data collection

Data were collected on 20 *C. brasiliense* adult trees (reproductive stage) at every 40 m along a 500 m transect at the site (Cerrado area, 10 ha), during 3 consecutive years. No fertilizers or pesticides were used in this area. The numbers of arthropods, defoliation, leaf miners, galls, termite nests and disease symptoms were recorded on 12 fully expanded leaves (three leaflets/leaf), 12 branches, 12 bunches of flowers, and 12 bunches of fruits - one plant part (e.g., leaf) in each vertical (apical, median, and basal = 0 to 33%, 34 to 66%, and 67 to 100% of total tree height, respectively) and horizontal (north, south, east, and west) stratifications of the canopy, on 20 *C. brasiliense* trees. Sampling was performed in the morning (7:00-11:00 A.M) by direct visual observation or hand lens -10 x magnification, three fields/leaf with 1cm^2 of the fixed field - for phytophagous and predator mites (immature and adults sum), once a month. Each month, these trees were also evaluated by the number of trunk borers attacked by Cossidae (Lepidoptera) (number of roles per trunk) and termite nests.

The number of fruits was counted in a bunch per side of the crown (north, south, east, and west) and along with the canopy (apical, middle, and basal) of the 20 trees, monthly, in the Cerrado area. The total production of fruits/tree was obtained by multiplying the total number of bunches per tree by the number of fruits per bunch evaluated.

Insects were collected with tweezers, brushes, or aspirators and preserved in vials with 70% alcohol for identification by taxonomists (see acknowledgments). The leaves were collected and transported to the laboratory. Subsequently, the leaves were placed inside a white plastic pot (temperature 25°C) and the emergence of galling insects, parasitoids, hyperparasitoids, and inquilines was evaluated per sample every two days for 30 days. The emerged insects were collected and preserved as described for identification (see acknowledgments). In the case of mites, these arthropods were collected in the leaves when they arrived in the laboratory, with brushes - (using a binocular microscope with 12.5 × magnification), and preserved in vials with 70% alcohol for identification (see acknowledgments).

3. Results

The loss sources (*L.S.*), per individual or symptom (e.g., disease), *Edessa rufomarginata* De Geer, 1773 (Hemiptera: Pentatomidae) on fruits, fruit borer *Carmenta* sp. (Lepidoptera: Sesiidae), *E. rufomarginata* on leaves, trunk borer Cossidae, *Trigona spinipes* Fabr., 1793 (Hymenoptera: Apidae) on flowers, *Phomopsis* sp. (Sacc.) Bubák (Coelomyceto) on branches, *E. rufomarginata* on branches, fruit scraper *Naupactus* sp.1 (Coleoptera: Curculionidae) on fruits, *Aconophora* sp. (Hemiptera: Membracidae) on fruits, and leaf galling insect *Eurytoma* sp. (Hymenoptera: Eurytomidae) showed, among the 39 *L.S.*, the highest *% I.I.* (41.90, 18.58, 16.30, 10.48, 5.20, 3.66, 3.60, 0.24, 0.05, and 0.001%, respectively) on 20 *C. brasiliense* trees. The total number of loss of fruits and percentage of production reduction, respectively, per *L.S.*, on 20 *C. brasiliense* trees were:

E. rufomarginata on branches = 145.93 and 0.64%, *Phomopsis* sp. 57.43 and 0.25% on branches, *Carmenta* sp. 47.04 and 0.21% on fruits, *E. rufomarginata* on fruits 30.40 and 0.13%, *E. rufomarginata* on leaves 13.16 and 0.06%, *Eurytoma* sp. on leaves 4.99 and 0.02%, *Naupactus* sp.1 on fruits 4.01 and 0.02%, Cossidae 1.72 and 0.01% on trunks, *T. spinipes* on flowers 1.61 and 0.01%, and *Aconophora* sp. on fruits 0.68 and 0.003%, totalizing on 306.95 lost fruits and 1.35% of production reduction (Tables 2, 3). The attention levels (*A.L.*) for these *L.S.* were: *Phomopsis* sp. 0.05/branch; *E. rufomarginata* 0.04, 0.07, and 0.10 per branch, leaf, and fruit, respectively; *Carmenta* sp. 0.14/fruit; *T. spinipes* 1.92/flower; Cossidae 2.21/trunk; *Naupactus* sp.1 4.15/fruit; *Aconophora* sp. 11.91/fruit, and *Eurytoma* sp. 19.98/leaf on *C. brasiliense* tree (Tables 2, 3).

Table 2. Total number (*n*), reduction on production (*R.P.*), effectiveness of the solution (*E.S.*), key-source (*ks*), constancy (*c*), distribution source (*ds*), number of importance indice (*n.I.I.*), sum of *n. I.I.* (Σ*n.I.I.*), and percentage of *I.I.* by loss source (*L.S.*) or solution source (*S.S.*) by *L.S.* on 20 *Caryocar brasiliense* trees.

Loss sources								
L.S.	***n***	***R.P.***	***ks***	***c***	***ds***	***n.I.I.***	**Σ*n.I.I.***	***%I.I.***
E. rufomarginata (fr.)	38	0.800	0.021053	10	1.00	0.211	0.502	41.900
Carmenta sp. (fr.)	84	0.560	0.006667	14	1.00	0.093	0.502	18.578
E. rufomarginata (l.)	46	0.290	0.006304	13	1.00	0.082	0.502	16.295
Cossidae (t.)	16	0.107	0.006702	8	0.98	0.053	0.502	10.476
T. spinipes (f.)	26	0.062	0.002376	11	1.00	0.026	0.502	5.202
Phomopsis sp. (b.)	137	0.420	0.003066	6	1.00	0.018	0.502	3.661
E. rufomarginata (b.)	298	0.490	0.001644	11	1.00	0.018	0.502	3.600
Naupactus sp.1 (fr.)	210	0.019	0.000091	13	1.00	0.001	0.502	0.235
Aconophora sp. (fr.)	103	0.007	0.000065	4	1.00	0.000	0.502	0.051
Eurytoma sp. (l.)	5039	0.001	0.000000	20	1.00	0.000	0.502	0.001
Acaridae (l.)	1	0.000	0.000000	1	0.54	0.000	0.502	0.000
Histiostoma sp. (l.)	429	0.000	0.000000	18	1.00	0.000	0.502	0.000
Eutetranychus sp. (l.)	3	0.000	0.000000	1	1.00	0.000	0.502	0.000
Tetranychus sp.1 (l.)	32	0.000	0.000000	9	1.00	0.000	0.502	0.000
Tetranychus sp.2 (l.)	25	0.000	0.000000	9	1.00	0.000	0.502	0.000
Blattodea none identified (l.)	2	0.000	0.000000	2	0.48	0.000	0.502	0.000
C. cyphergaster (t. and b.)	57	0.000	0.000000	17	1.00	0.000	0.502	0.000
Oedionychus sp. (l.)	1	0.000	0.000000	1	0.54	0.000	0.502	0.000
D. speciosa (l.)	1	0.000	0.000000	1	0.54	0.000	0.502	0.000
Naupactus sp.1 (l.)	7	0.000	0.000000	5	0.95	0.000	0.502	0.000
Naupactus sp.2 (l.)	1	0.000	0.000000	1	0.54	0.000	0.502	0.000
Naupactus sp.3 (l.)	14	0.000	0.000000	4	1.00	0.000	0.502	0.000
R. stigma (l.)	4	0.000	0.000000	4	0.34	0.000	0.502	0.000
Apoptus sp. (l.)	11	0.000	0.000000	10	0.14	0.000	0.502	0.000
Camaria sp. (l.)	1	0.000	0.000000	1	0.54	0.000	0.502	0.000
Lepidopteran leaf miner	410	0.000	0.000000	20	1.00	0.000	0.502	0.000
Arctiidae (l.)	1	0.000	0.000000	1	0.54	0.000	0.502	0.000
Ctenuchiidae (l.)	2	0.000	0.000000	2	0.48	0.000	0.502	0.000
E. bechina (l.)	2	0.000	0.000000	2	0.48	0.000	0.502	0.000
Oecophoridae (l.)	2	0.000	0.000000	2	0.48	0.000	0.502	0.000
A. reticulatum (l.)	1	0.000	0.000000	1	0.54	0.000	0.502	0.000

I.I. = *ks* x *c* x *ds*. *ks* = *R.P.*/total *n* of the *L.S.* or *E.S.*/total *n* of the *S.S.*. *R.P.* or *E.S.* = R^2 x (1 - *P*) when it is of the first degree, or *R.P.* or *E.S.* = ((R^2 x (1 - *P*)) x(β_2/β_1) when it is of the second degree, R^2 = determination coefficient and *P* = significance of ANOVA, β_1 = regression coefficient, and β_2 = regression coefficient (variable²), of the simple regression equation. *c* = Σ of occurrence of *L.S.* or *S.S.* on each sample, 0 = absence or 1 = presence. *ds* = 1 - *P* of chi-square test of the *L.S.* or *S.S.*. When a *S.S.* operates in more than one *L.S.*, its *E.S.* are summed. *R.P.* or *E.S.* = 0 when *R.P.* or *S.S.* non-significant with reduction on production or of the *L.S.*. b. = branch, f. = flower, fr. = fruit, l. = leaf, and t. = trunk.

Table 2. Continued...

Loss sources								
L.S.	***n***	***R.P.***	***ks***	***c***	***ds***	***n.I.I.***	**Σ*n.I.I.***	***%I.I.***
A. reticulatum (f.)	4	0.000	0.000000	1	1.00	0.000	0.502	0.000
B. tabaci (l.)	2	0.000	0.000000	2	0.48	0.000	0.502	0.000
A. gossypii (l.)	33	0.000	0.000000	3	1.00	0.000	0.502	0.000
Mahanarva sp. (l.)	8	0.000	0.000000	5	0.97	0.000	0.502	0.000
D. caryocar (l.)	741	0.000	0.000000	19	1.00	0.000	0.502	0.000
Frequenamia sp. (l.)	12	0.000	0.000000	5	1.00	0.000	0.502	0.000
Aconophora sp. (l.)	16	0.000	0.000000	6	1.00	0.000	0.502	0.000
Aconophora sp. (f.)	18	0.000	0.000000	2	1.00	0.000	0.502	0.000
Pseudococcus sp. (l.)	33	0.000	0.000000	6	1.00	0.000	0.502	0.000
Hymenoptera none identified (l.)	49	0.000	0.000000	11	1.00	0.000	0.502	0.000
Hymenoptera None identified (f.)	2	0.000	0.000000	2	0.48	0.000	0.502	0.000
Eulophidae (l.)	79	0.000	0.000000	19	0.92	0.000	0.502	0.000
Bruchophagus sp. (l.)	14	0.000	0.000000	8	1.00	0.000	0.502	0.000
O. flavicornis (l.)	1	0.000	0.000000	1	0.54	0.000	0.502	0.000
Solution sources								
S.S.	***n***	***E.S.***	***ks***	***c***	***ds***	***n.I.I.***	**Σ*n.I.I.***	***%I.I.***
Z. armillatus (l.)	14	0.166	0.043298	10	0.44	0.190	0.342	55.475
Crematogaster sp. (l., f., and fr.)	489	1.849	0.003781	20	1.00	0.076	0.342	22.082
Epipolops sp. (l.)	21	0.091	0.004342	11	0.94	0.045	0.342	13.130
P. termitarius (l. and fr.)	18	0.146	0.008104	13	0.30	0.031	0.342	9.173
A. magistretti (l.)	284	0.007	0.000024	19	1.00	0.000	0.342	0.131
Sycophila sp. (l.)	1592	0.003	0.000002	19	1.00	0.000	0.342	0.009
Proctolaelaps sp. (l.)	53	0.000	0.000000	3	1.00	0.000	0.342	0.000
Agistemus sp. (l.)	61	0.000	0.000000	12	1.00	0.000	0.342	0.000
Spiders (l. and f.)	33	0.000	0.000000	16	0.78	0.000	0.342	0.000
Calosoma sp. (l.)	2	0.000	0.000000	1	0.99	0.000	0.342	0.000
N. fulgurata (l.)	15	0.000	0.000000	5	1.00	0.000	0.342	0.000
Alycaulini (l.)	117	0.000	0.000000	15	1.00	0.000	0.342	0.000
Quadrastichus sp. (l.)	35	0.000	0.000000	12	1.00	0.000	0.342	0.000
Chrysoperla sp. (l.)	3	0.000	0.000000	2	0.95	0.000	0.342	0.000
Holopothrips sp. (l.)	20	0.000	0.000000	13	0.48	0.000	0.342	0.000
Trybonia sp. (l.)	152	0.000	0.000000	12	1.00	0.000	0.342	0.000

I.I. = *ks* x *c* x *ds*. *ks* = *R.P.*/total *n* of the *L.S.* or *E.S.*/total *n* of the *S.S.*. *R.P.* or *E.S.* = R^2 x (1 - *P*) when it is of the first degree, or *R.P.* or *E.S.* = ((R^2 x (1 - *P*)) x(β_2/β_1) when it is of the second degree, R^2 = determination coefficient and *P* = significance of ANOVA, β_1 = regression coefficient, and β_2 = regression coefficient (variable²), of the simple regression equation. *c* = Σ of occurrence of *L.S.* or *S.S.* on each sample, 0 = absence or 1 = presence. *ds* = 1 - *P* of chi-square test of the *L.S.* or *S.S.*. When a *S.S.* operates in more than one *L.S.*, its *E.S.* are summed. *R.P.* or *E.S.* = 0 when *R.P.* or *S.S.* non-significant with reduction on production or of the *L.S.*. b. = branch, f. = flower, fr. = fruit, l. = leaf, and t. = trunk.

The effective solution sources (*S.S.*), per individual, predator *Zelus armillatus* (Lep. and Servi., 1825) (Hemiptera: Reduviidae) on leaves, *Crematogaster* sp. (Hymenoptera: Formicidae) on leaves (mean 10.80±1.81 S.E.), flowers (mean 10.40±2.96 S.E.) and fruits (mean 3.25±1.36 S.E.), *Epipolops* sp. (Hemiptera: Geocoridae) on leaves, *Pseudomyrmex termitarius* (Smith, 1877) (Hymenoptera: Formicidae) on leaves (mean 0.85±0.16 S.E.) and fruits (mean 0.05±0.05 S.E.), and *Eurytoma* sp. parasitoids *Ablerus magistretti* Blanchard, 1942 (Hymenoptera: Aphelinidae) and *Sycophila* sp. (Hymenoptera: Eurytomidae) on leaves, showed, among the 16 *S.S.*, the highest *% I.I.* (55.48, 22.08, 13.13, 9.17, 0.13, and 0.01%, respectively) on 20 *C. brasiliense* trees. *Crematogaster* sp. reduced production loss per *Carmenta* sp. on fruits, *E. rufomarginata* on branches, on fruits, and in leaves, *Eurytoma* sp. on leaves, and

Table 3. Loss sources (*L.S.*), loss of production by loss source (*L.P.L.S.*), % of *L.P.L.S.*, and attention level (*A.L.*); effectiveness of the solution (*E.S.*) per solution source (*S.S.*), income gain (*I.G.*) and its %, and non-attention level (*N.A.L.*) by *S.S* and partial and total sum (Σ) on 20 *Caryocar brasiliense* trees.

Loss of production by loss source				
L.S.	***L.P.L.S.***	***% L.P.L.S.***	***n per sample***	***A.L.***
E. rufomarginata (b.)	145.932	0.641	0.034	0.040
Phomopsis sp. (b.)	57.425	0.252	0.016	0.047
E. rufomarginata (l.)	13.156	0.058	0.005	0.069
E. rufomarginata (fr.)	30.400	0.133	0.018	0.099
Carmenta sp. (fr.)	47.040	0.206	0.039	0.141
T. spinipes (fl.)	1.606	0.007	0.018	1.921
Cossidae (t.)	1.716	0.008	0.022	2.213
Naupactus sp.1 (fr.)	4.007	0.018	0.097	4.146
Aconophora sp. (fr.)	0.684	0.003	0.048	11.905
Eurytoma sp. (l.)	4.988	0.022	0.583	19.979
Total Σ	**306.954**	**1.348**	---	---
Increase in production per solution source and total				
		E. rufomarginata (b.)		
S.S.	***E.S.***	***I.G.***	***% I.G.***	***N.A.L.***
Crematogaster sp.	0.470	68.525	0.301	0.106
Σa	---	**68.525**	**0.301**	---
		E. rufomarginata (l.)		
Crematogaster sp.	0.286	3.765	0.017	0.306
Σb	---	**3.765**	**0.017**	---
		E. rufomarginata (fr.)		
Crematogaster sp.	0.680	20.672	0.091	0.184
P. termitarius	0.146	4.434	0.019	0.857
Z. armillatus	0.317	9.639	0.042	0.394
Σc	---	**34.745**	**0.152**	---
		Carmenta sp. (fr.)		
Crematogaster sp.	0.399	18.765	0.082	0.439
Σd	---	**18.765**	**0.082**	---
		Naupactus sp.1 (fr.)		
Crematogaster sp.	0.006	0.024	0.0001	849.453
Z. armillatus	0.166	0.665	0.003	31.261
Σe	---	**0.689**	**0.003**	---
		Eurytoma sp. (l.)		
A. magistretti	0.007	0.033	0.0001	3735.130
Crematogaster sp.	0.008	0.041	0.0001	3062.411
Epipolops sp.	0.091	0.455	0.002	273.878
Sycophila sp.	0.003	0.013	0.0001	9941.293
Z. armillatus	0.123	0.614	0.003	31.261
Σf	---	**1.156**	**0.005**	---
Total Σ=Σa+...+f	---	**127.646**	**0.560**	---

L.P.L.S. = total *n* of the *L.S.* x *R.P.* of the *L.S.*. *Maximum Estimated Production* (*M.E.P.*) = *Total production* (*P.*) + Σ $L.P.L.S._1$ + ...$L.P.L.S._n$. *M.E.P.* = 22782 (22475 + 307). *% L.P.L.S.* = (*L.P.L.S.*/*M.E.P.*) x 100. *n* of the *L.S.* per sample = *n*/(number of trees/evaluation frequency/years/number of plant parts evaluated). Tree = 20; 12 months per year for leaves, trunks and branches, two months for bunches of flowers per year, and three months for bunches of fruits per year; three years; and 12 leaves, 12 bunches of flowers and/or fruits, and one trunk per tree/evaluation. *Attention level* (*A.L.*) = (*n* of the *L.S.* per sample x 0.75)/*% L.P.L.S.*. 0.75 = 1% of loss fruits x 0.75 (safety margin). *I.G.* = *L.P.L.S.* x *E.S.*. *% I.G.* = (*I.G.*/*M.E.P.*)*100. *Non-attention level* (*N.A.L.*) = (*A.L.* x 1.25)/*E.S.* 1.25 = 25% plus as safety margin. *E.S.* of *S.S.* are separated by *L.S.*. b. = branch, f. = flower, fr. = fruit, l. = leaf, and t. = trunk.

Naupactus sp.1 on fruits (18.77, 68.53, 20.67, 3.77, 0.04, and 0.02 total saved fruit – *I.G.*, respectively) increasing in % of income gain (0.082, 0.301, 0.091, 0.017, 0.0001, and 0.0001%, respectively) on *C. brasiliense* production. *Pseudomyrmex termitarius* decreased production loss (4.43 total saved fruit) per *E. rufomarginata* on fruits increasing in income gain (0.019%) on *C. brasiliense* production. The predator *Z. armillatus* decreased production loss per *E. rufomarginata* on fruits, *Eurytoma* sp. on leaves, and *Naupactus* sp.1 on fruits (9.64, 0.61, and 0.67 total saved fruit, respectively) increasing in percentage of income gain (0.042, 0.003, and 0.003%, respectively) on *C. brasiliense* production. The parasitoids *A. magistretti* and *Sycophila* sp. and the predator *Epipolops* sp. decreased production loss per *Eurytoma* sp. on leaves (0.03, 0.01, and 0.46 total saved fruit, respectively) increasing in percentage of income gain (0.0001, 0.0001, and 0.0020%, respectively) on *C. brasiliense* production. The total reduction in production loss due to loss sources was 127.65 total saved fruit, with an increase in system productivity of 0.56% due to the solution sources cited above. The non-attention levels (*N.A.L.*) for these *S.S.* were: i) *Crematogaster* sp.: 0.44 for *Carmenta* sp. on fruit; 0.11, 0.18, and 0.31 for *E. rufomarginata* on the branch, on fruit, and in leaf, respectively; 3062.41 for *Eurytoma* sp. on the leaf, and 849.45 for *Naupactus* sp.1 on fruit; ii) *P. termitarius*: 0.86 for *E. rufomarginata* on fruit; iii) *Z. armillatus*: 0.394 for *E. rufomarginata* on fruit, 31.261 for *Eurytoma* sp. on the leaf, and 31.26 for *Naupactus* sp.1 on fruit; iv) 3735.13 *A. magistretti*, 9941.29 *Sycophila* sp. and 273.88 *Epipolops* sp. for *Eurytoma* sp. on the leaf, on one plant part evaluated/*C. brasiliense* tree (Tables 2, 3).

4. Discussion

The Percentage of Importance Indice (*% I.I.*) effectively identified the loss sources on the system. The use of *% I.I.* is for cases in which it is impossible to evaluate all flowers and fruits of all plants in the experimental useful plot, identifying the factors of plant loss (Demolin-Leite, 2021). Fruit production and arthropods on branches, flowers, fruits, leaves, and trunks data, used to test *% I.I.*, were collected on *C. brasiliense* trees, over 10 m high, randomly, in the Cerrado area, in three years, monthly. Flowers and fruits were evaluated on some tree branches and then estimated the total per tree, thus, the use of this index is for cases where it is not possible to use a Crop Life Table (Demolin-Leite, 2021).

The loss sources *E. rufomarginata*, *Carmenta* sp., Cossidae, *T. spinipes*, *Phomopsis* sp., *Naupactus* sp.1, *Aconophora* sp., and *Eurytoma* sp. showed the highest *% I.I.* on 20 *C. brasiliense* trees, reducing, around 1.4%, the fruit production (less ≈ 307 total fruits). The *% I.I.* shows the importance of these loss sources, observing the individual capacity to cause damage and if the attack occurs in an aggregate and frequent way in the samples. With this index, it is possible to separate these loss sources on production, assuming a cutoff point (e.g., *% I.I.* below 1%). Therefore, it would be unnecessary to calculate *L.P.L.S.*, *% L.P.L.S.*, and *A.L.* such as for *Naupactus* sp.1 (*% I.I.* = 0.235) and *Aconophora* sp. (*% I.I.* = 0.051) on fruits and *Eurytoma* sp. (*% I.I.* = 0.001) on leaves on *C. brasiliense* trees, showing highest *A.L.* (4.15/fruit, 11.91/fruit, and 19.98/leaf, respectively) and, consequently, *N.A.L.* (e.g., *Sycophila* sp. versus *Eurytoma* sp. = 9941.29/leaf) per plant part/tree/evaluation.

The sap-sucking *E. rufomarginata* on branches, leaves, and fruits, and fruit borer *Carmenta* sp. are related, causing fall of flowers and fruits and damaging fruits, respectively, reducing the production of *C. brasiliense* trees (Leite et al., 2012a, 2016). *Edessa rufomarginata* and *Carmenta* sp. showed very low *A.L.* (0.04/branch, 0.07/leaf, 0.10/fruit, and 0.14/fruit respectively) on *C. brasiliense* trees. A suggestion of control tactic for *E. rufomarginata* is the collection of fallen leaves and their burial, during the renewal of leaves and flowering of *C. brasiliense* trees (Leite et al., 2006), as *E. rufomarginata* takes refuge under these leaves, while waiting for the new leaves. The same applies to *Carmenta* sp., as the bored fruits must be collected and buried so this pest does not complete its life cycle. The lower percentage of live *C. brasiliense* trees and healthy branches were found in the Savanna of Ibiracatu, Minas Gerais, Brazil, where only 30% of the trees were healthy and without visible signs of attack by trunk borer Cossidae and, principally, by fungus *Phomopsis* sp. (Leite et al., 2012b). Cossidae showed *A.L.* of 2.2/trunk and *Phomopsis* sp. *A.L.* 0.05/branch. The control of Cossidae is relatively easy; sprinkling is performed in the active holes in the trunk (with fresh sawdust), with entomopathogenic fungus *Beauveria bassiana* powder. However, the control of *Phomopsis* sp. is not easy. One indication of control is the cutting and burial of the branches when they present the first attack symptoms.

Moreover, *T. spinipes* is a pest that can reduce pollination on *Cucurbita moschata* Dusch (Cucurbitales: Cucurbitaceae) plants owing to insufficient pollen transportation (small body size) and/or chasing other pollinators by flying in flocks and with aggressive behavior (Serra and Campos, 2010). In addition, *T. spinipes* damages shoots and plant growth regions by removing fibers to construct their nests, as reported on *Acacia mangium* Willd. (Fabales: Fabaceae) and *Leucaena leucocephala* (Lam.) de Wit. (Fabales: Fabaceae) (Silva et al., 2014; Damascena et al., 2017; Silva et al., 2020; Gomes et al., 2023; Lima et al., 2024), besides it damages flowers such as *Zantedeschia aethiopica* (L.) Spreng. (Commelinales: Araceae) (Carvalho et al., 2018). *Trigona spinipes* showed *A.L.* of 1.92/flower and, traditionally, what is recommended is the location and destruction of its nest.

The *% I.I.* was, also, effective in identifying solution sources on the system. The use of *% I.I.* is for cases in which it cannot mark and monitor the animal, identifying the cause of its mortality (Demolin-Leite, 2021), as done by Ecological Life Table (Henderson and Southwood, 2016). The evaluation of herbivorous insects and their natural enemies, including spiders, on *C. brasiliense* trees, was not done individually during their lives, nor would it be possible due to the height of these plants in Cerrado areas. But, with the application of this index, it was possible to determine the effects of these natural enemies on herbivores and fruit production per tree on the natural system.

The solution sources *Z. armillatus*, *Crematogaster* sp., *Epipolops* sp., *P. termitarius*, *A. magistretti,* and *Sycophila* sp.

showed the highest *% I.I.* on *C. brasiliense* trees, increasing on system productivity by 0.56% (≈ 128 total saved fruits). Similar to the loss sources of production, this index showed the individual capacity of the natural enemies to reduce damage per *L.S.*, and if the predation attack occurs in an aggregate and frequent way in the samples (Demolin-Leite, 2021). *Crematogaster* sp. reduced production loss per *Carmenta* sp. on fruits and *E. rufomarginata* on fruits, branches, and leaves, with *N.A.L.* of 0.44, 0.18, 0.11, and 0.31 per plant part/tree/evaluation, respectively; and those of *Z. armillatus* and *P. termitarius* that of *E. rufomarginata* on fruits, with *N.A.L.* of 0.39 and 0.86, respectively, per plant part/tree/evaluation.

The percentage of defoliation by herbivorous Lepidoptera and Coleoptera had a negative correlation with *Crematogaster* sp. and *P. termitarius* on *C. brasiliense* trees (Leite et al., 2012c), but *Crematogaster* sp. increased the abundance of *Dikrella caryocar* (Coelho, Leite and Da-Silva, 2014) (Hemiptera: Cicadellidae) and *Pseudococcus* sp. (Hemiptera: Pseudococcidae) on these trees (Leite et al., 2015). *Caryocar brasiliense* loses its leaves in August/September with new ones in September (Leite et al., 2006). The ants *Crematogaster* sp. and *P. termitarius* were more abundant during the formation of new leaves and flowers, with positive correlations, at end of the winter, probably due to the nectaries of leaves and flowers (Leite et al., 2012c, 2012d). Higher ant visitation to extrafloral nectaries can favor the production of flowers or fruits and reduce damage on *C. brasiliense* trees by herbivorous insects, such as *Eunica bechina* Talbot, 1928 (Lepidoptera: Nymphalidae), *E. rufomarginata*, *Prodiplosis floricola* (Felt, 1907) (Diptera: Cecidomyiidae), and petiole gall insects (Hymenoptera: Chalcidoidea) (Freitas and Oliveira, 1996; Oliveira, 1997; Leite et al., 2012d). The *Zelus* genus is an efficient predator in natural systems and commercial crops (Zhang et al., 2016). The predators *Epipolops* sp. and *Z. armillatus* and parasitoids *A. magistretti* and *Sycophila* sp., a major *Eurytoma* sp. parasitoid, are important in controlling galling insect *Eurytoma* sp. (Leite et al., 2017). However, *Z. armillatus* may prefer attacking *Eurytoma* sp. galls parasitized by *Sycophila* sp., evidence of "prudence strategy" (Leite et al., 2017), whereby predators fed on parasitized prey, preserving the healthy prey as a food reserve for future generations, without endangering prey populations (Slobodkin, 1968).

5. Conclusions

The *% I.I.* separated the loss sources (e.g., *Carmenta* sp. on fruits = 18.58%) on production reduction (e.g., 0.21%) and the solution sources (e.g., *Crematogaster* sp. = 11.61%) with total income gain (e.g., 0.56%) on the natural system (e.g., *C. brasiliense* trees), with the possibility to calculate, monetarily, these losses or effectiveness of the solutions. The *% I.I.* can help, to determine which pests, e.g. exotic mammals, insects, plant diseases, and weeds, cause the biggest problems in plant production and the best control methods (e.g., biological control) are more harmful or effective on the system (e.g., crops) and how much money is lost or saved. Here I tested the *%I.I.* This index can detect the loss or solution key-sources on a system, making it possible to obtain loss and income gain on some knowledge areas.

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