Revealing land-use change as a key factor influencing the incidence of envenomation by *Lonomia* spp. in southern Brazil

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Introduction

Larvae of the genus *Lonomia* (Lepidoptera: Saturniidae) have a wide medical interest in South America, since two of their species are considered as etiological agents of Lonomism. The accidental contact of humans with the stinging structures of the species promotes a type of intoxication characterized by a systemic compromise, with severe hemorrhagic conditions in several organs, which complications can lead to death.

The first official cases of accidents involving the genus *Lonomia* were attributed to *L. obliqua* Walker 1855. Such cases occurred in the late 1980s, in the state of Rio Grande do Sul (Brazil). Several accidents involving this species have also been recorded in the states of Santa Catarina and Paraná. Due to the large number of victims, the Brazilian sanitary authorities decided to produce a specific antivenom, which production is carried out by the Butantan Institute since 1996 and is the only effective treatment to avoid complications and consequently the death of patients.

Recently, the records of the major sites of lonomic accidents are from anthropic areas bordering primary forest areas (LEMAIRE, 2002). There are hypotheses that relate human occupation, especially the growth of agricultural regions in proximity to forest areas, to the occurrence of lonomic accidents. It is possible that the constant environmental changes resulting from the anthropic factors on the use and occupation of the land unbalance the ecological relations of *Lonomia* spp., causing the displacement of species to new environments to obtain resources (LEMAIRE, 2002; LORINI, 1999). Not being restricted to natural forests, *Lonomia* spp. would pose a greater danger to human being, which has become more susceptible to accidents. However, none of these hypotheses has yet been confirmed.

Thus, in the present study, it is proposed the use of historical data of lonomic accidents, based on on land use and climate, as a way to identify factors that promote significant effects for occurrence of lonomic accidents in southern Brazil.

Hypotheses / Models

Table 1 – Test of Hypotheses on causes of lonomic accidents using Generalized Linear Models (GLM) and Generalized Linear Mixed Model (GLMM) (Data distribution families: Poisson, Null Binomial and Binomial).

Model	Land use				Climate				Random effect
	%Fo	%AF	%F	%A	TAWQ	RAWQ	ΔT	ΔP	City
0(null)									X*
1	X								X*
2		X							X*
3			X						X[1]
4				X					X[1]
5					X				X[1]
6						X			X[1]
7							X		X[1]
8								X	X[1]
9	X	X							X[1]
10					X	X			X[1]
11							X	X	X[1]
12	X	X			X	X			X[1]
13	X	X					X	X	X[1]
14	X	X			X	X	X	X	X[1]

X* - Random effect variable used in GLMM.
% Fo -% of forestry/City (IBGE - https://www.ibge.gov.br/).
%AF - % of native vegetation bordering agriculture areas/City (IBGE)
% AF - % of areas of native vegetation bordering agriculture areas/City (IBGE).
% F - % of primary forests areas/City (IBGE).
% A - % of agricultural areas/City (IBGE).
TAWQ - T°C average of the warmest quarter/City (WordClim 2.0 - http://www.worldclim.org/).
RAWQ – Rainfall average of the warmest quarter (mm)/City (WordClim 2.0).
ΔT - T°C average of the warmest quarter - T°C average of the coldest quarter (WordClim 2.0).
ΔP - Rainfall average of the warmest quarter - Rainfall average of the coldest quarter (WordClim 2.0).

The dependent variables are: Count of lononomics accidents per city between 2000-2006 / Presence-absence of lononomics accidents per city between 2000/2006 (n=1.191 citys) (DATASUS - www.datasus.gov.br/).

Notes about the models

1. The null model represents the null hypothesis of random variation of lonomic accidents among the cities of southern Brazil.
2. The models in the category "land use" consider the hypotheses that lonomic accidents would be related to human occupation, mainly on what concerns the agricultural and forestry occupation.
3. The models on the "climate" category represent the general hypothesis that physiological restrictions imposed on larvae of *Lonomia* spp. by climate (temperature and rainfall) could drive accidents. For that, the temperature and the rainfall of the warmest quarter - larval period of the species - and Δ's of temperature and rainfall (average of the warmest period - average of the coldest period) were considered.
4. Joint models considering different combinations of “land use” and “climate” variables. From the execution of the models that considered the variables isolated, combinations of the significant variables were also performed.

Results

Using the AIC, BIC and dispersion quotient between the deviation and DF of the residuals, the adequacy of each model was evaluated for the best representation of the data of lonomics accidents per city. Thus, it was verified that the models of the GLM type with binomial distribution family presented a better fit among all tested models (table 2).

Table 2 - index values (minimum - maximum) calculated for the models set.

Models	Index	Distribution family		
		Poisson	Null Binomial	Binomial
GLM	AIC	6177.302 – 7446.033	2255.016 – 2374.605	1130.149 – 1236.476*
	BIC	6212.88 – 7451.116	2295.677 – 2384.769	1165.727 – 1241.559*
	Dev./DF	4.6061 – 5.6591	0.4752 – 0.4922	0.9427 – 1.0381*
GLMM	AIC	1217.965 – 2214.493	1219 – 2216.388	1132.145 – 1238.476
	BIC	1258.627 – 2224.658	1265.714 – 2231.635	1172.805 – 1248.642
	Dev./DF	0.0464 – 0.6362	0.0463 – 0.63667	0.9936 – 1.0389*

* Models that presented the lowest values of AIC and BIC, as well as values of Dev./GL ~ 1.

Among GLM/binomial models, model 14 (BM14) presented the best result for the indices (AIC = 1130.149; BIC = 1165.727; Dev./GL = 0.95). From the BM14 model, it is possible to verify that the predictors of land use %Fo (OR: 5.40, OR 95% IC: 1.19 - 24) and %AF (OR: 2.53, OR 95% CI: 1.13 - 5.78) promote a greater risk for the occurrence of lonomic accidents (Table 3). The climatic variable TAWQ is a protective factor for accidents (OR: 0.90; OR 95% CI: 0.69 - 0.92), in which cities with extreme values present a smaller number of accidents (table 3). The other climatic factors, even when significant, were not very informative in terms of risk, all being very close to zero effect (Table 3).

Table 3 - Model adjusted for the presence of acc. in southern Brazil (**p <0.05**).

Predictors	Estimate	Odds Ratio	OR CI 95%	p
(Intercepto)	-4.5019	**0.01**	0.00 – 0.31	**0.008**
%S	1.6856	**5.40**	1.19 – 24.00	**0.028**
%AF	0.9268	**2.53**	1.13 – 5.78	**0.026**
TAWQ	-0.2215	**0.80**	0.69 – 0.92	**0.003**
RAWQ	0.0128	**1.01**	1.01 – 1.02	**<0.001**
ΔT	0.2410	**1.27**	0.94 – 1.73	0.118
ΔP	-0.0059	**0.99**	0.99 – 1.00	**<0.001**

The results corroborate the hypotheses that relate the human occupation (agricultural and forestry) with lonomic accidents. The few forest remnants left in the southern Brazil region, with the intensification of agriculture and forestry, show that the suppression of native vegetation has caused environmental imbalances that lead to lonomic accidents.

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- **Analyzes carried out in Software R:**

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