

Urban Chagas Disease in San Juan. Diagnosis, Review, and Proposal for an Integrated Attack System

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ABSTRACT

The city of San Juan, Argentina, located in a poorly irrigated oasis, has always been an area with high prevalence of Chagas disease. Ecological, social, and environmental changes in the pathogen complex indicate that *Triatoma infestans*, the vector of the disease, is moving from rural areas –its traditional habitat– to urban zones. This paper discusses the procedures used to quantify this phenomenon, as well as the techniques of cartographic representation. After analyzing geographical and historical issues of the problem, the current link between the kissing bugs and the doves is examined. Doves are not capable of hosting the agent *Trypanosoma cruzi* in their bloodstream; they are rather reservoirs that facilitate the vector's transportation. To conclude, the problem should be tackled through an integrated strategy that considers the pathogen complex with transdisciplinary criteria.

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Key words > Chagas Disease - Doves - Urbanization - *Trypanosoma cruzi* - *Triatoma infestans* - *Columba livia*

INTRODUCTION

Located in the Cuyo region –in the west of Argentina–, the province of San Juan has well-defined geographical characteristics: strong influence of the relief (particularly the Andes, the Andean Foothills, and the Pampean Hills), a hydric regime bound up to the defrosting that flows in very desertic areas, and a habitat grouped in oasis, areas of low irrigation where most of the economic activities take place.

In this place, the Chagas disease had and still has a significant importance, to the point that it is considered one of the main attack frontages for the national programs dealing with this issue. At present, the local responsibility falls on the Provincial Vector Control Program, a unit of the Ministry of Public Health of San Juan. This unit works with federal support as a research and control center, and develops an on-site method of work that resembles Dr. Salvador Mazza's style, whose pioneering work in the province (1) goes back to several decades ago.

The pathogen complex is developed around an agent –the unicellular parasite *Trypanosoma cruzi*– and its vectors –a wide variety of triatomines, out of which the *Triatoma infestans* is found in San Juan–, and it was traditionally considered to be bound up to rural life. This was explained through the relation-

ship between the disease cycle and a complementary wild circuit in which several vertebrates acted as reservoirs and hosted the agent. The breeding animals from the peridomiciliary area, especially dogs and hens, played a similar role in the surroundings of the huts made from adobe and straw. The triatomines (commonly known as kissing bugs) protected themselves in the cracks of this area and got out at night to parasite on humans (90% on children, the most exposed ones).

These environmental conditions, which were studied and fought against by Salvador Mazza more than fifty years ago, are different today. This reason applies worldwide, but has a special incidence in places like San Juan: seduced by urban life, people increasingly abandon their houses in the country (and, of course, their habits).

As opposed to other vectors –for instance, the *Aedes aegypti*, the mosquito that spreads the dengue and the yellow fever–, the kissing bug responds to a refined adaptation etiology. The first ones, together with all those small and short-lived organisms that have a strong dependence on the limits imposed by the environment, adopt what is called the “R-strategy”, which consists of reproducing themselves on a large scale to balance their survival expectancy. The kissing bugs, on the contrary, respond to the “K-strat-

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egy”, which emphasizes the possibilities of adaptation of each individual not only to the environment but also to its eventual changes. (2) It is not strange, then, that an adaptation process for the triatomines to new niches of the urban habitat could be expected, particularly because one of the key factors in the pathogen complex –the human being– is massively moving to the cities.

This phenomenon should not be taken lightly. The urbanization processes are slow and respond to many reasons that differ a lot among themselves, depending on their social and territorial conditions. Other cities are showing similar processes. In Arequipa, for example, it is talked about a pathology “that is beginning to be different, compared to the one registered in a rural Chagas pathogen complex”. (3, 4)

CHAGAS PATHOGEN COMPLEX

This work gathers information about the Chagas pathogen complex, obtained from the Provincial Vector Control Program. The statistic registries collected by this agency were processed by the Program of Medical Geography of the National University of San Juan.

The method used was the centralization of data by unifying the files through digitalized relational databases, which could be organized through geographic information systems.

The main hypothesis raises from the evidences of the vector urbanization, by substitution of the wild links and the strong influence of birds (particularly the rock dove –*Columba livia*–), which not only are they parasited by the *Triatoma infestans*, but they also collaborate with its convergent spread towards the center of the city and, consequently, its radication.

In order to contrast this hypothesis, the report of the cases were encouraged through a media campaign. The detected triatomines came from brick houses –not from huts, as it could be expected–; the departments integrated to the city of San Juan, such as Capital, Rawson, and Chimbas, are included in the registry.

This office carried out an intradomiciliary survey in downtown blocks, and selected all information available according to different scales –decreasing, in concentric direction– in order to map the presence of adult kissing bugs and nymphs found or reported in different areas of Gran San Juan. Such selection starts in the province, continues throughout the whole urban cluster in the Tulum oasis, and then steps into the area limited by the *Circunvalación* avenue (which approximately coincides with the Capital municipality), and with the old compound of the city, represented by 135 blocks centralized at 31° 32' latitude south and 68° 31' longitude west.

The historic geography was used to understand the changes of the pathogen complex, and successive cross-sections were performed to be able to analyze former landscapes. The periods chosen correspond to 1880 –

the last times of San Juan as a small village–, to 1944 –juncture in which there was an earthquake that caused the total collapse of the buildings–, and to the present time.

To supplement the evidence about the link between kissing bugs and doves, a survey among people was carried out to gather opinions about the density and the focus in which both species develop, following centripetal transections of the four cardinal directions. These results were spatially represented and compared to the cartograms on vacant lots and squares, especially favorable to this convergence.

GEOGRAPHY OF THE INFECTION

On the occasion of processing the blood tests obtained through medical check-ups in men before their military service –mandatory in Argentina until 1992–, San Juan showed a high prevalence of the Chagas disease. According to the evaluation of the *Comisión Internacional del Cono Sur* (International Commission of the South Cone), San Juan and five other provinces (La Rioja, Córdoba, Santiago del Estero, Chaco, and Formosa) made up the group with the highest risk in the areas considered endemic (about two thirds of the continental territory of Argentina). In this context, integrated actions were implemented, coordinating tasks such as fumigation, laboratory, and consultation, with other still non-systematized tasks. Educational and research projects also joined this campaign.

According to data from 2006, San Juan still occupied the 2nd place in intradomiciliary infection (with 35%, just below Santiago del Estero) and peridomiciliary infection (with 21%, just below San Luis). The 8 acute cases registered in 1997 (5 patients were younger than 10 years old) were progressively reduced to 7, 4, and 3, until the year 2000. After a year with no registration, from 2002 to 2005 there was a case per year, localized in the south of Gran San Juan, under the jurisdiction of the department of Rawson. Since then, there has been no reported cases. It is important to note that in this period (a decade), out of the 26 registered cases of vectorial transmission, 15 (most of them children) were patients who lived in the city, 10 corresponded to rural-urban inhabitants, and only 1 case (2.6%) to rural inhabitants.

The historical geography shows how San Juan evolved, as a territory ecological and socially suitable for the development of the Chagas pathogen complex.

In 1895, only 12% of the population in the province lived in the capital city, which had approximately 20,000 inhabitants. These percentages increased gradually: 18% in 1914, 32% in 1947, 42% in 1960, 58% in 1970, 62% in 1980, 70.4% in 1991, and 70.5% in 2001. At present, the cluster of Gran San Juan has surpassed the 500,000 inhabitants. (5)

By the end of the 19th century, the city was scarcely comprised of four avenues, which are now the commercial and administrative center. These blocks sur-

rounded the major square, where the main social, political and religious activities took place. A few blocks away from this center, lifestyle was absolutely rural, in close contact with vine arbors and grazing lands typical of an agricultural economy that alternated with precarious and isolated industrial ventures, such as wine cellars and windmills.

The pathogen complex was at the town entrance, near the reservoirs of wild animals, which were capable of strengthening the cycle through their vector, the kissing bug. The kissing bug, whose capacity for moving is scarce, had the chance to approach in breeding animals and pets, in the bales of pasture, and in the firewoods, which were consumer goods usually brought to the city. Stables and chicken coops were the usual places where these bugs concentrated, together with some other vermins. Their threat was still unknown, although some historical data show the presence of the disease in cardiomegaly reports found *post mortem*. It is reasonable to believe that the influence of ischemic pathologies (especially of sudden death) was not a main concern in a population whose life expectancy rate was nearly half of the rate nowadays. It should be taken into account that death due to Chagas disease generally occurs after the development of the chronic stage, that is to say, above and beyond 50 years.

From this city-village, we pass on to the cross-section that corresponds to the half of the last century. In this period, the city of San Juan gathered almost half the total population of the province. The vitiviniculture had spread to become a central –and often exclusive– activity in the economy. Two levels were identified in the habitat: the level of the rural population in the oasis –often reinforced with seasonal human migration–, and the level of the owners of production goods, who lived mainly in the city.

The earthquake in 1944 resulted in the destruction of the adobe houses, and gave way to a new antiseismic building style, incompatible with the vector's "needs". This period coincides with the generalized action against the Chagas disease in Argentina. Since then, the scourge was recognized, studied, and attacked by disinfecting the huts and their surrounding areas or peridomiciliaries (chicken coops, pigsties, woodsheds, etc.). In turn, during this stage the triatomines had to face a process of adaptation, and they did it by developing "K-strategies".

It should be considered that the vectorial transmission was, at those times, the main channel to spread the disease. Due to its characteristics, this transference is difficult to materialize, since it is produced as a result of a complex cycle in which the *Triatoma infestans* bites a mammal, and the mammal becomes infected and spreads the *Trypanosoma cruzi* on the human being. For this cycle to take place, it is necessary that the following circuit be met: *bite* ® *inversion* ® *defecation* ® *scratching* ® *parasite pen-*

etration ® *proliferation in the blood stream*; all these stages gradually reduce the statistical possibility of the transmission.

The rural areas of San Juan "after the earthquake" –especially in houses and farms of the oasis in Tulum, Ullum, and Zonda, near the capital city, but also in other distant regions like Jáchal, Rodeo, Iglesia, Calingasta, Barreal, and Media Agua, with enough demographic stock of population– were suitable for the disease to continue spreading, due to the favorable conditions for a persistent vectorial transmission. It should be taken into account that the Chagas disease in endemic zones has a stronger effect. The occasional infected individuals present a lower cardiac involvement than those who have been exposed day after day and have been inoculated many times; "this situation would determine, on the one hand, the parasite role and the *Tripanosoma cruzi* strains; and, on the other hand, the role of the inflammatory and immunological mechanisms". (6)

The last cross-section corresponds to the present time. A fast growth lead San Juan to 500,000 inhabitants. Its central structure ended up becoming refractory of a pathogen complex of rural type. However, interim, new conditions were set in motion. The registers of reported cases start to provide interesting data: the huts (type C) are no longer the most affected houses; the best built houses (A), located in the most expensive neighborhoods are now the most affected (Table 1).

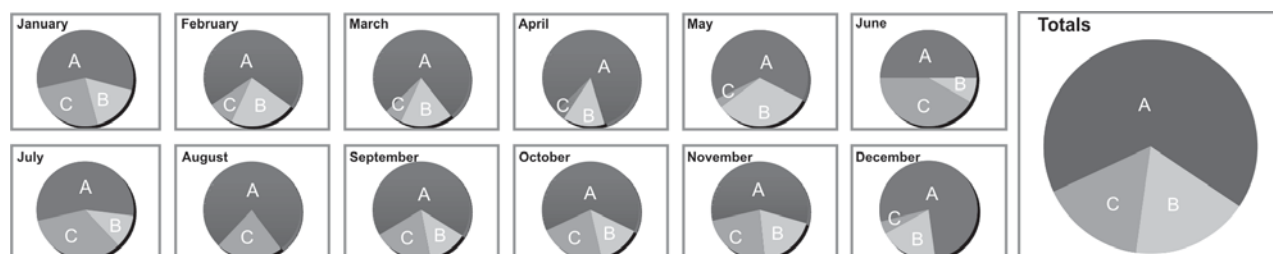
The surrounding rural sectors experienced a process of depopulation: there was no point in having producers and contractors in a mechanized agricultural system, organized with high performance irrigation methods. The wild cycle of the classic complex became a system capable of taking advantage of the concentration of animals with cosmopolitan habits. Among these animals, it is important to set a difference: the birds can be considered a reservoir of the vector, but not of the agent. A kissing bug can parasite on a hen or a duck (and, in fact, it often does), but the *Trypanosoma cruzi* does not have the ability to develop in its blood and, therefore, cannot return to the cycle through that channel.

The central issue considered in this work resides in this hosting condition that birds have, in spite of interrupting the pathogen cycle of the complex. There are other birds with herd etiology and domestic behavior that are assuming a significant role in the Chagas pathogen complex. The domestic dove, exotic in America, is becoming a key factor in the urbanization process of the triatomines, because they imprint new characteristics to this system.

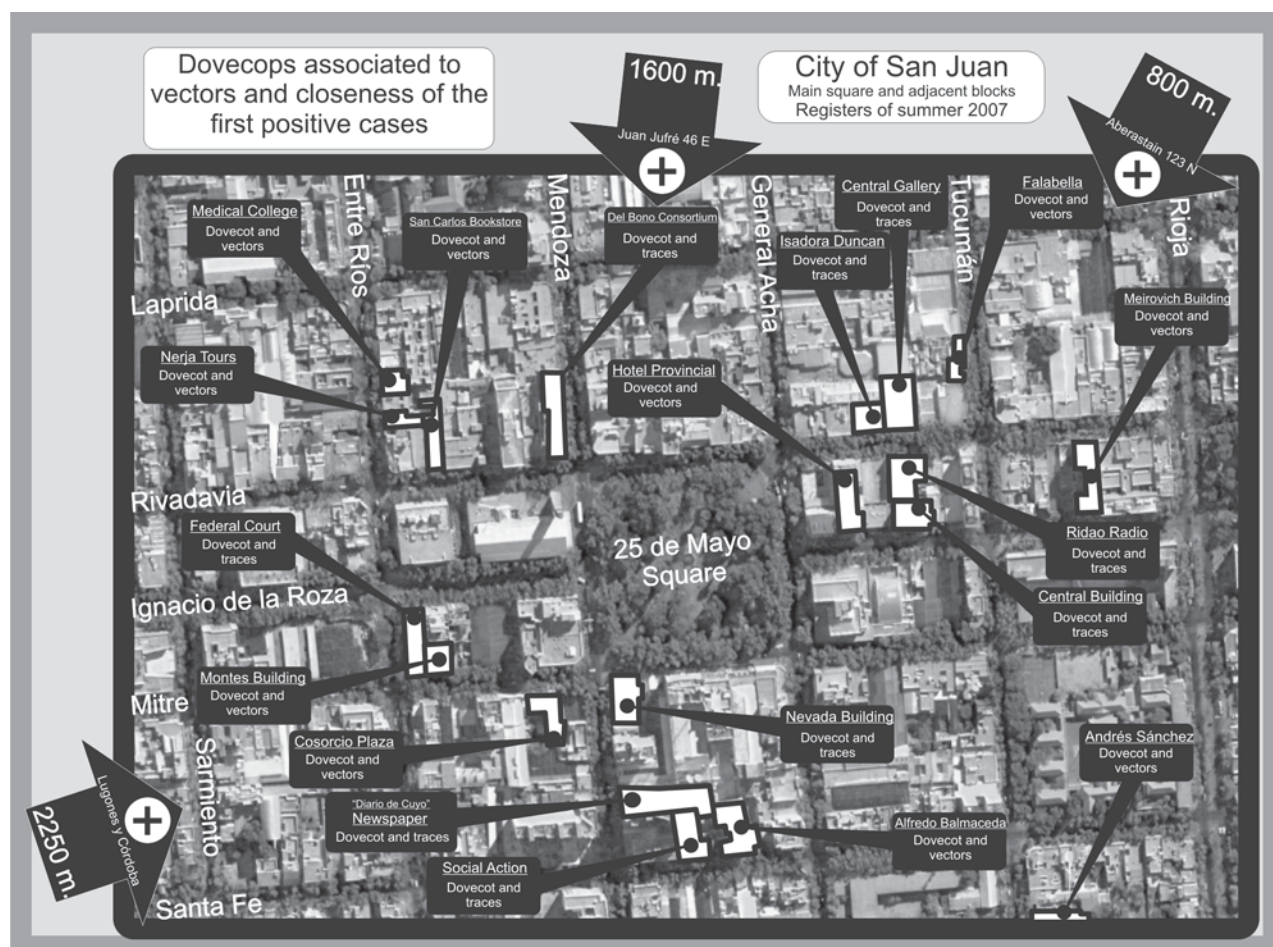
An evidence of this is the campaign that started at the end of 2007, with control and disinfection, not in the rural sector but in the surrounding area of the main square (Figure 1). The finding of huge urban dovecots (the largest one: an eight-floor building,

Table 1. Types of homes affected. San Juan, 2007

Type	January	February	March	April	May	June	July	August	September	October	November	December	Total and %
A	142	112	119	47	22	6	5	7	31	77	91	75	734 66,49
B	41	35	27	8	11	1	1	0	6	17	30	19	196 17,75
C	63	14	9	2	1	5	3	2	9	26	36	4	174 15,76
Total	246	161	155	57	34	12	9	9	46	120	157	98	1104 100



Note: Type-A homes correspond to cement houses, with antiseismic structure (even the social houses of the kind built by IPV-FONAVI home plans); type-B homes may be built of cement (concrete blocks with no joint sealing, Lote Hogar type), adobe, or both; type-C homes are huts made of mud or other temporary materials, and are generally emergency homes.

**Fig. 1.** Downtown dovecots.

abandoned but totally invaded by doves and kissing bugs, located at scarcely 200 meters from the urban epicenter) reveals a serious situation. The opinion survey among the inhabitants confirmed that it is a dynamic phenomenon that increases and spreads from the periphery to the center (Figure 2).

In order to compare, between 2006 and 2007 the monthly reported information on vectors was mapped by the Provincial Vector Control Program; their condition (adult or nymphs) and the result of the laboratory analysis (positive or negative) were registered. The mapping (Figure 3) applies a criterium based on four concentric scales: as it has been mentioned, province, oasis, capital city, and old compound, whose data are excluded with respect to the ascending levels.

The classic situation can be seen in the distant departments (especially Calingasta, Iglesia, Jáchal, Valle Fértil, and Sarmiento). These departments have the highest percentage of nymphs (46.38% of the total vectors reported and under research). Out of a thousand adults, 23 were identified as positives and 44,800 of the nymphs were in that situation (Table 2). The core of the city, limited by the four avenues, is in the other end, with 3 cases registered as positive, and a proportion of nymphs that is above the 1 to 3 relation. The data from the Capital department, within the Circunvalación avenue, is very significant. The *Trypanosoma cruzi* infection rate is the highest one, for both adults and nymphs. In both cases, it far surpasses the media in the province (twice in the first case, and more than three times for the nymphs).

FINAL COMMENTS

Taking into consideration these results, it can be argued that there is a gradual urbanization process that should be considered for future actions regarding vector control. It is not ventured to extend the hypothesis to other regions of the country, where the concentration levels of population are similar. To better evaluate this dynamics, it is necessary to take some aspects into account: the most important of these aspects is considering the city *in toto* as a pathogen complex, submitted to strong socio-economic and technological tensions.

A phenomenon as such implies the necessity to be studied, but also the execution of precautionary control actions. To act immediately and efficiently, it is necessary to resort to the joint intervention of physicians, biologists, and geographers, together with experts from other disciplines, in a transdisciplinary approach. As history demonstrates, the disinfecting process of houses and other risky places is also a key factor, but it cannot be limited to a solipsist action, without the link to research teams. Finally, this union will not be effective if it is not focused directly on the community. To do that, it is necessary to link national and provincial programs, with the participation of representatives from the community live forces –congregated in discussion forums– that adopt measures to be then transferred to their political and institutional area of application.

In this process, the different ways to reach the affected population through the massive media are a key factor. However, the key to success in giving an answer to the impact of the Chagas pathogen com-

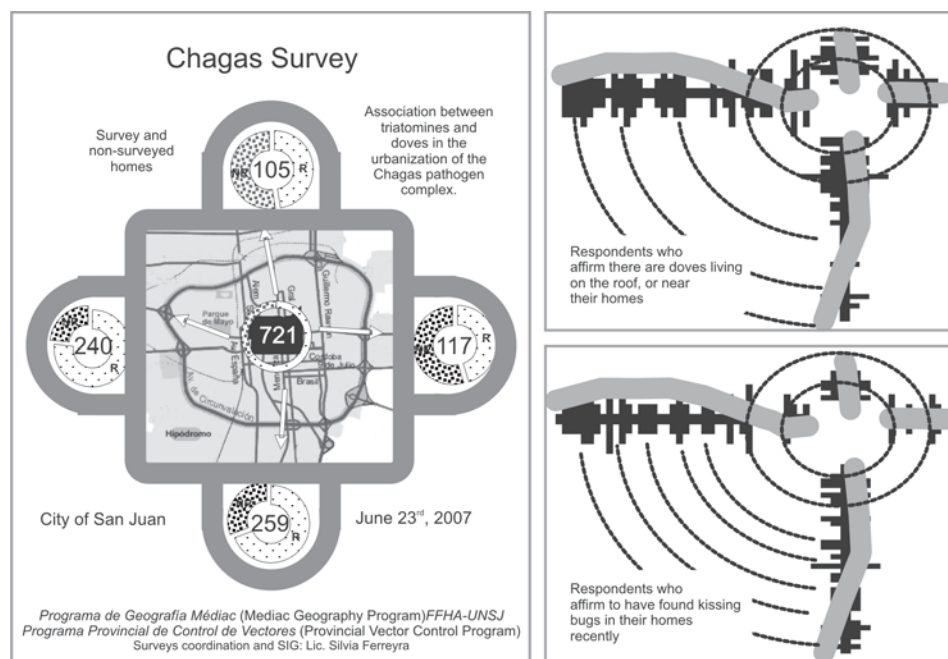


Fig. 2. Opinion survey among the population.

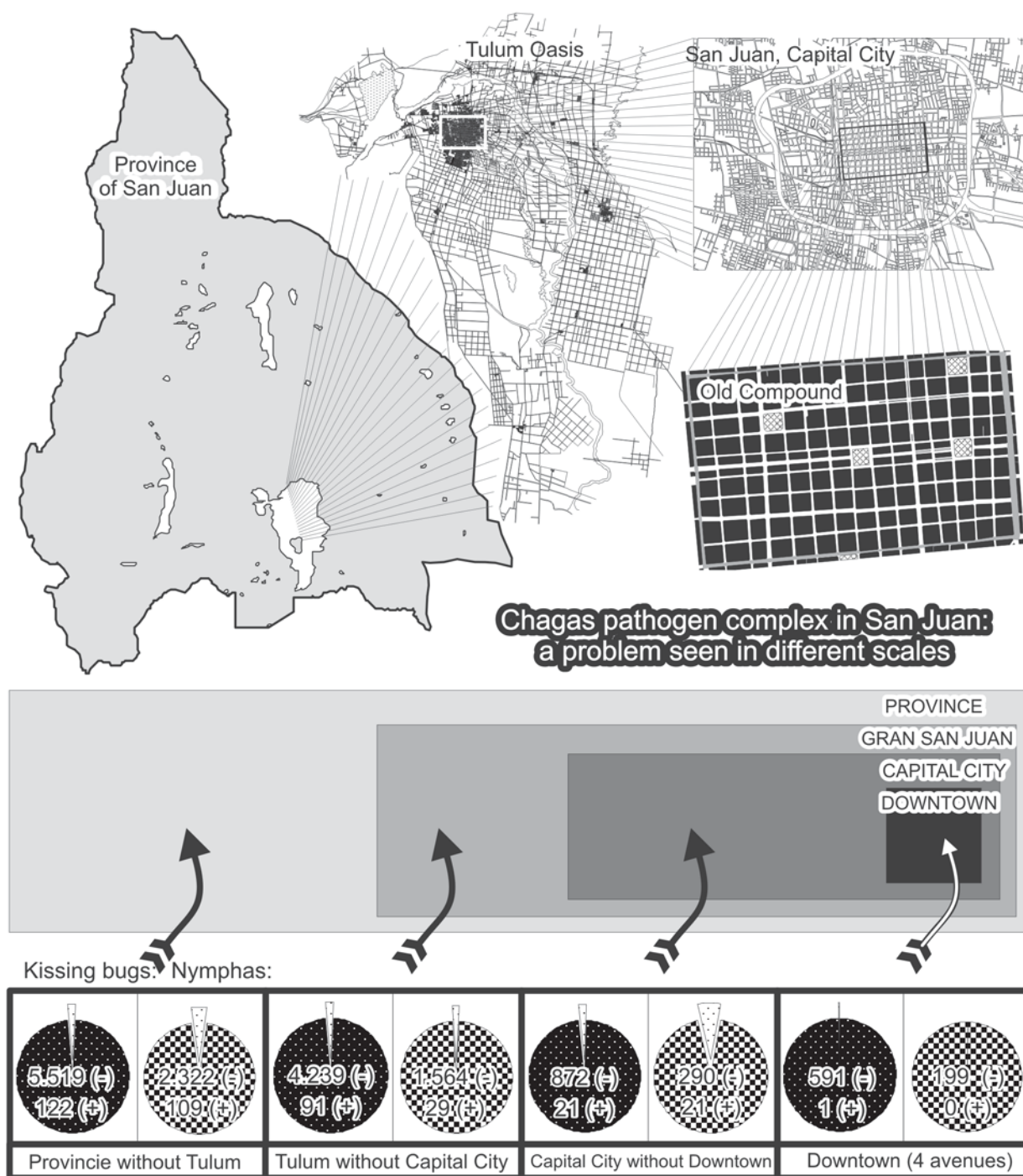


Fig. 3. Chagas pathogen complex in San Juan. Mapping of the information on vectors.

plex is in education. The province of San Juan carried out major advances in the fight against the Chagas disease thanks to the students' intervention, encouraged by an active team of teachers, who, at present, carry out multiple functions: they provide information to their families and, through them, to the whole community; they help people become aware of the seriousness of the problem; they become agents for control; they detect the most risky focus and connect the vectors to the laboratory; and, from the edu-

cational level, they plan the objectives for prevention and control recommended by the academic work centers. To sum up, they set a bridge of information between the two ends of the problem.

As a complement, the following graphic (Figure 4) shows different operation and registration stages that are developed in San Juan. In this way, it is intended to give an answer to a pathogen complex with an operative complex, in which none of the parts can work if they are not associated with one another.

Mazza Institute: Chagas Research Seen as an Integrated Program

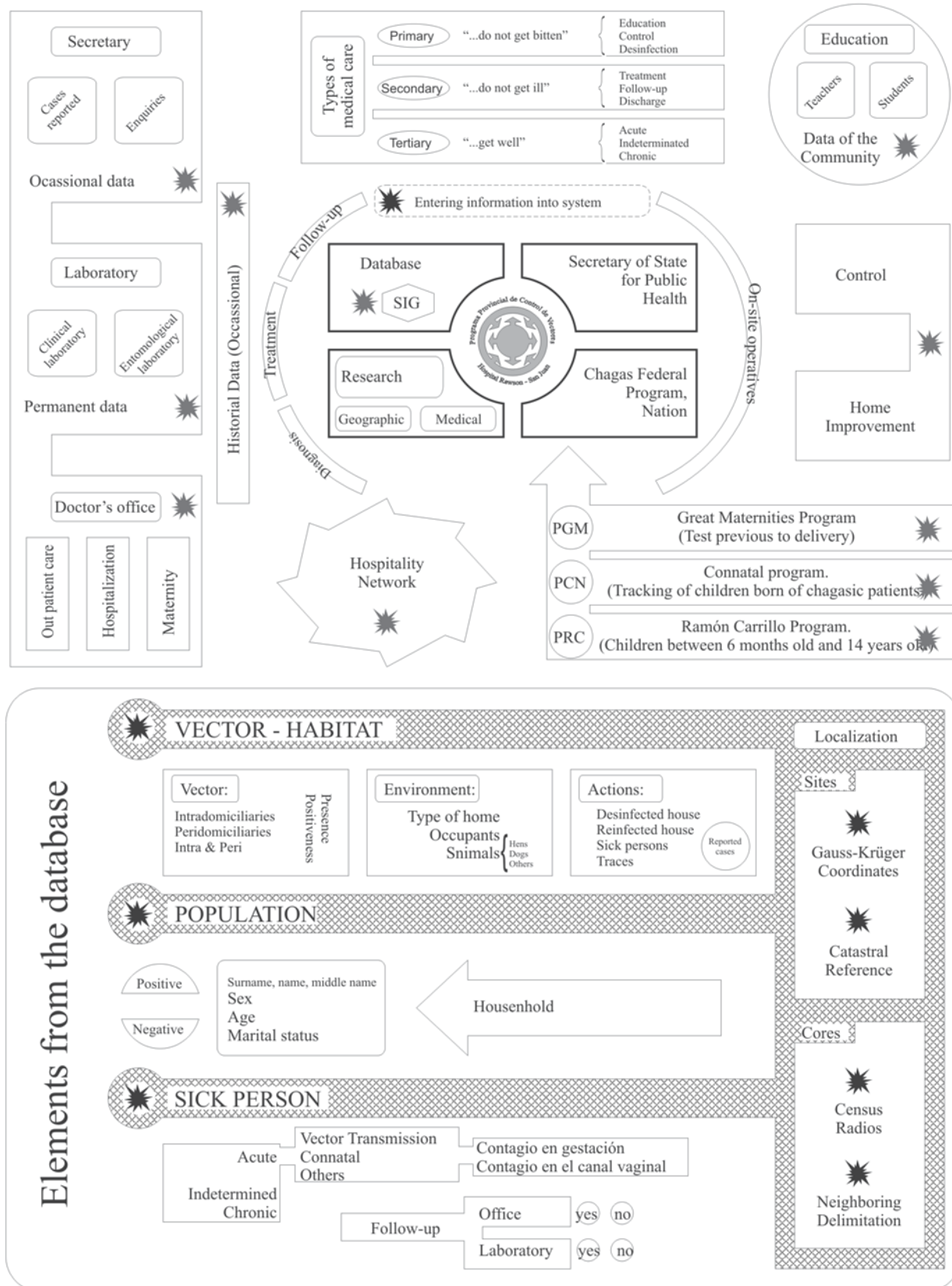


Fig. 4. Integrated research.

Table 2. *Triatoma infestans*. Data for San Juan obtained by report and control, according to scales. 2006/2007

Levels		2006																								2007												Total 2006/7
		Jan-06	Feb-06	Mar-06	Abr-06	May-06	Jun-06	Jul-06	Agg-06	Sep-06	Oct-06	Nov-06	Dic-06	Total 2006	Jan-07	Feb-07	Mar-07	Abr-07	May-07	Jun-07	Jul-07	Aug-2007	Sep-07	Oct-07	Nov-07	Dic-07	Total 2007											
Scale I: Old compound	Houses studied	20	26	26	8	3	1	1	1	8	12	13	15	134	43	21	18	6	3	0	2	1	7	10	13	14	138	272										
	Total kissing bugs	22	33	57	57	6	2	1	1	13	16	39	18	265	50	42	84	30	3	0	2	1	18	44	24	28	326	591										
	Total nymphas	1	3	33	30	4	1	0	1	3	5	12	2	95	8	10	38	10	0	0	1	0	12	24	1	1	105	200										
	Adults +	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1											
	Nymphas +	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
Scale II: Capital	Houses studied	34	44	34	14	3	5	0	2	8	29	46	37	256	38	34	38	10	6	1	0	0	5	20	22	15	189	445										
	Total kissing bugs	38	91	116	23	3	34	0	2	13	42	86	44	492	85	65	65	61	8	3	0	0	22	37	39	16	401	893										
	Total nymphas	3	33	47	9	1	23	0	1	3	10	33	4	167	24	27	22	32	2	0	0	0	12	11	12	2	144	311										
	Adults +	1	1	8	0	0	0	0	0	0	2	1	2	15	2	0	2	0	0	0	0	0	0	0	0	0	2	21										
	Nymphas +	0	0	17	1	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	1	2	3											
Scale III: Tulum Oasis	Houses studied	53	81	61	38	25	10	5	5	50	152	188	91	759	78	87	85	35	22	4	5	6	21	50	59	49	501	1,260										
	Total kissing bugs	80	858	257	65	229	14	24	6	386	446	392	236	2993	164	207	432	88	41	4	17	7	40	131	112	94	1337	4,330										
	Total nymphas	20	382	117	16	102	4	8	3	137	135	121	48	1093	65	86	185	33	11	0	2	3	16	56	20	23	500	1,593										
	Adults +	1	11	1	1	0	2	0	0	7	11	15	12	61	0	4	2	1	0	0	0	0	0	5	5	13	30	91										
	Nymphas +	0	1	0	0	0	0	0	0	4	5	5	4	19	2	2	0	0	1	0	0	0	0	0	0	1	4	10										
Scale IV: Province	Houses studied	27	42	22	38	17	17	3	6	0	73	128	61	434	85	19	14	6	2	7	2	2	13	40	63	13	266	700										
	Total kissing bugs	279	223	220	695	639	101	195	34	0	572	312	195	3465	832	36	49	12	10	86	24	2	68	320	258	79	1776	5,241										
	Total nymphas	90	111	135	390	296	101	75	34	0	254	86	52	1624	386	19	21	2	8	55	10	1	35	179	78	13	807	2,431										
	Adults +	1	1	0	2	0	0	25	0	0	0	8	11	48	39	0	0	0	0	0	0	0	2	1	31	1	74	122										
	Nymphas +	10	4	0	6	5	1	5	1	0	0	6	7	45	35	0	1	0	0	0	0	0	17	0	11	0	64	109										

RESUMEN

Chagas urbano en San Juan. Diagnóstico, revisión y propuesta para un sistema integrado de ataque

La ciudad de San Juan, Argentina, inserta en un oasis bajo riego, es y fue un área de fuerte prevalencia de la enfermedad de Chagas. Cambios ecológicos y socioambientales del complejo patógeno indican un avance significativo de su vector, *Triatoma infestans*, desde las zonas rurales, su hábitat tradicional, hacia el centro urbano. En este artículo se discuten los procedimientos empleados para medir este fenómeno, así como las técnicas de representación cartográfica. Tras un análisis geohistórico del problema, se revisa la situación actual a partir del vínculo entre vinchucas y palomas, estas últimas en su condición de reservorios, no facultados para albergar en su torrente sanguíneo el agente *Trypanosoma cruzi* pero sí para facilitar la movilidad del vector. Se concluye que resulta necesario atacar el problema a través de una estrategia integrada que considere el complejo patógeno con criterio transdisciplinario.

Palabras clave > Enfermedad de Chagas - Palomas - Urbanización - *Trypanosoma cruzi* - *Triatoma infestans* - *Columba livia*

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