Triatominae
Vectors of Chagas Disease
Dr. C. J. Schofield

Triatominae
Vectors of Chagas Disease

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1

Triatoma infestans

No family should be obliged to live with these bugs

2

Carlos Chagas
1878-1934

3

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Acute Phase
Romaña’s sign, fever, lymphadenopathy
mortality: 5-15%

Chronic phase
Cardiopathy
Mega Syndrome
(south of Amazonia)

Chagas disease: estimates of prevalence

Chagas disease in the Americas 1990

Seroprevalence Incidence*

Mexico
1 300 000
20 854

Central America
1 770 000
61 823


Andean Pact
2 300 000
62 485

(Col. Venez. Ecuad. N.Peru)

Southern Cone
11 500 000
303 004


TOTAL
16 870 000
448 166

* Incidence calculated using the model of Hayes & Schofield (1990)
Chagas disease
Average cost (US$) of supportive treatment per case during different phases of the infection

<table>
<thead>
<tr>
<th>Phase</th>
<th>Cost per Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACUTE PHASE</td>
<td>434.85</td>
</tr>
<tr>
<td>CHRONIC PHASE</td>
<td></td>
</tr>
<tr>
<td>Indeterminate (asymptomatic form)</td>
<td>129.93</td>
</tr>
<tr>
<td>Symptomatic form with cardiac lesions</td>
<td></td>
</tr>
<tr>
<td>a. Uncomplicated</td>
<td>336.19</td>
</tr>
<tr>
<td>b. Complicated, requiring pacemaker</td>
<td>1628.18*</td>
</tr>
<tr>
<td>Symptomatic form with megasyndrome</td>
<td></td>
</tr>
<tr>
<td>a. Not requiring surgery</td>
<td>602.27</td>
</tr>
<tr>
<td>b. Requiring corrective surgery</td>
<td>687.06*</td>
</tr>
</tbody>
</table>

Data from Del Rey et al., (1993) for Salta, Argentina

* Note that surgical costs have been amortised over average life expectancy after intervention; Without amortisation, average costs are $4440.25 for pacemaker implant, and $1603.67 for intestinal surgery

Chagas disease – economic impact 1990

<table>
<thead>
<tr>
<th>Region</th>
<th>Seroprevalence</th>
<th>Incidence</th>
<th>Cost ($/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>1 300 000</td>
<td>20 854</td>
<td>180 141 705</td>
</tr>
<tr>
<td>Central America</td>
<td>1 770 000</td>
<td>61 823</td>
<td>329 794 745</td>
</tr>
<tr>
<td>Andean Pact</td>
<td>2 300 000</td>
<td>62 485</td>
<td>391 007 353</td>
</tr>
<tr>
<td>Southern Cone</td>
<td>11 500 000</td>
<td>303 004</td>
<td>1 947 301 820</td>
</tr>
<tr>
<td>TOTAL</td>
<td>16 870 000</td>
<td>448 166</td>
<td>2 848 245 623</td>
</tr>
</tbody>
</table>

Chagas disease control methods

1. Diagnosis and treatment of acute cases (and young chronic cases)
   Nifurtimox
   Benznidazole

2. Symptomatic and supportive treatment for chronic cases
3. Serological screening of mothers;
   parasitological diagnosis and treatment of newborns
4. Serological screening of blood donors
5. VECTOR CONTROL
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Classification of the Triatominae

Hemiptera
  Coleorrhyncha
Heteroptera
  Auchenorrhyncha
  Sternorrhyncha

75 families
Reduviidae
23-32 subfamilies
Triatominae

Triatominae

<table>
<thead>
<tr>
<th>Tribes</th>
<th>Genera</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberprosenini</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Bolboderini</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cavernicolini</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Rhodiniini</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Triatomini</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Development cycle of *Panstrongylus megistus*

A - eggs; B - first stage nymph; C - second stage nymph; D - third stage nymph; E - fourth stage nymph; F - fifth stage nymph; G - adult female.
Consequences (for the family) of domestication of Triatominae

- Nuisance (including psychological difficulties)
- Chronic blood loss (on average, 2.5 ml per person per day)
- Risk of transmission of Trypanosoma cruzi

Consequences (for the bugs) of the domestication of Triatominae

- Protection against climatic extremes
- Protection against some predators
- Rich and consistent food sources
- Results
  1. Reproduction all year
  2. Low mortality
  3. High population density

\[ \frac{dN}{dt} = rN(1 - \frac{N}{K}) \]

\[ R_0 = \frac{N_f}{N_0} \]
Density regulation in domestic Triatominae

- Vertebrate predators
- Egg parasitoids
- Exposure to predators
- Nutritional status
- Development time
- Rate of egg-laying
- Temperature
- Feeding
- Competition

Consequences of population stability

When $R_0 \gg 1$

- 200 offspring
- 99%

Each generation can only give rise to the same number of parents; Consequently, the remainder do not reach reproductive age

SILVATIC
- Founder effect
- Isolation from original gene pool

DOMESTIC
- Selection for optimum genotype

Selection for optimum genotype

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Genetic consequences of domestication of Triatominae

- Selection for individuals of greatest energetic efficiency
- Tendency to genetic monomorphy in each population
- Tendency to low genetic variability within each population

**Consequences**
- Size reduction
- Reduced likelihood of selection for resistance

Vector control methods

**Insecticides** – pyrethroids
- Insect Growth Regulators – precocenes, juvenile hormones
- Insect Pathogens – fungi (Metarrhizium, Beauveria), nematodes (Neocaplectana)
- Biological Control – egg parasitoids (Telenomus, Ooencyrtes), predators
- Genetic Control – sterile males, GMOs (Nocardia)
- Traps – kairomones, pheromones, light

**Housing Modifications** – wall plaster, roof, floor

**Health Education**

Insecticides used against domestic Triatominae

1947 – DDT ineffective
1948 – gamma-BHC (HCH, Lindane) Highly effective, but no longer used
1956 – dieldrin (widely used in Venezuela)
1970 – organophosphates, carbamates no advantages over OCs
1980 – pyrethroids highly cost-effective
- Deltamethrin 25 mg a.i./m²
- Lambda-cyhalothrin 30 mg a.i./m²
- Cyfluthrin 50 mg a.i./m²
- Alphacypermethrin 50 mg a.i./m²
- Cypermethrin 125 mg a.i./m²
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### Venezuelan campaign against Chagas disease 1966-1980

- **Arnaldo Gabaldón**
- % seropositivo
- 44.44% 1955-66
- 11.69% 1980-84

<table>
<thead>
<tr>
<th>Age-group</th>
<th>0-0</th>
<th>10-19</th>
<th>20-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50+</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955-66</td>
<td>60</td>
<td>50</td>
<td>40</td>
<td>30</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>1980-84</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
</tr>
</tbody>
</table>

### Control of Chagas disease in the State of São Paulo

- 1964-1967 attack phase (Arrastão)
- 1968-1972 selective respraying
- 1973-1983 general surveillance
- 1984-1989 surveillance by locality
- 1990- surveillance by priority areas

- Seropositivity 1985-1991
- 20 years after the attack phase

### Brazilian municipalities

- (a) Municipalities of Brazil where Triatoma infestans was captured in houses during 1975-83
- (b) Municipalities still positive for T. infestans in 1986, three years after beginning the current vector control programme

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How do you maintain political priority when circumstances change?

Trypanosomiasis vectors: the reinestation problem

\[ N = E. p(a), p(D \geq d) \]

Source population

Target house

The Technical Response:
- Develop formulations of longer residual action
  - But no treatment will protect the target house forever

The Strategic Response:
- Eliminate also the source populations
  - This means very large-scale intervention programmes
  - Bringing challenges for programme coordination

- 6 million square kilometres
- 7 countries
- Domestication of wild guinea-pigs in central Bolivia was thought to have been the initial role for domestication of Triatoma infestans

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Operational strategy (domestic Triatominae)

Infestation
Attack threshold
Detection level

Attack phase (mass intervention)

Vigilance phase (selective intervention)

Time

Apparent distribution of *Triatoma infestans*

Predicted Maximum 6,278,081 km² (Gorla 2002)

Current Estimate 913,485 km² (Approx.)

Multinational control initiatives

2000 Mexico
1997 Central America
1997 Andean Pact
2002 Amazonia
1991 Southern Cone

2007: Non-endemic countries (including USA)
1. Scientific and operational experience
2. Uruguay free of T. infestans transmission 1997
3. Chile free of T. infestans transmission 1999
4. Brazil free of T. infestans transmission 2006
   (also several regions of Argentina and Paraguay)
5. Guatemala free of R. prolixus transmission 2008
   (also, probably, El Salvador and Nicaragua)
6. Approx. 60 million people no longer have to sleep in bug infested houses
7. Approx. 10 million people not infected
8. High rate of economic return
   for an expenditure of approx $400 million
   SC countries have eliminated costs of around
   $2800 million (Brazilian figures) or $8500 million (Argentine figures)
9. The overall economic return has been equivalent to 30 - 64%
   (according to method of calculation)
10. Renewed confidence in large-scale control programmes

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Chagas disease – future challenges
1. Extend and Consolidate the advances made
2. Elimination of domestic Triatominae in all countries
3. Surveillance and focal vector control interventions
   - peridomestic foci
   - adventitious silvatic species
   - oral route-transmission
4. Surveillance and Specific treatment for new acute cases
5. Diagnosis, Supportive and Specific treatment
   for those already infected
6. Chagas disease in “non-endemic” countries

…The Punishment of Success…!