

**ECOLOGICAL NICHE MODELING AND
DIFFERENTIATION OF POPULATIONS OF
TRIATOMA BRASILIENSIS NEIVA, 1911, THE MOST IMPORTANT
CHAGAS DISEASE VECTOR IN NORTHEASTERN BRAZIL
(HEMIPTERA, REDUVIIDAE, TRIATOMINAE)**

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Supported by APHL, CDC, NHF (Brazil)



INTRODUCTION

- **W**ITH SUCCESSFUL CONTROL MEASURES AGAINST *TRITOMA INFESTANS*, THE MAIN CHAGAS DISEASE VECTOR IN BRAZIL, GREAT PROGRESS HAS BEEN MADE IN COMBATING THIS DISEASE. CURRENTLY, ANOTHER SPECIES, ***T. BRASILIENSIS***, IS THE MOST IMPORTANT VECTOR IN SEMIARID AREAS OF NORTHEASTERN BRAZIL.

INFESTED AREAS BY *T. INFESTANS* BRAZIL, 1983/1996

(Silveira & Vinhaes 1999)

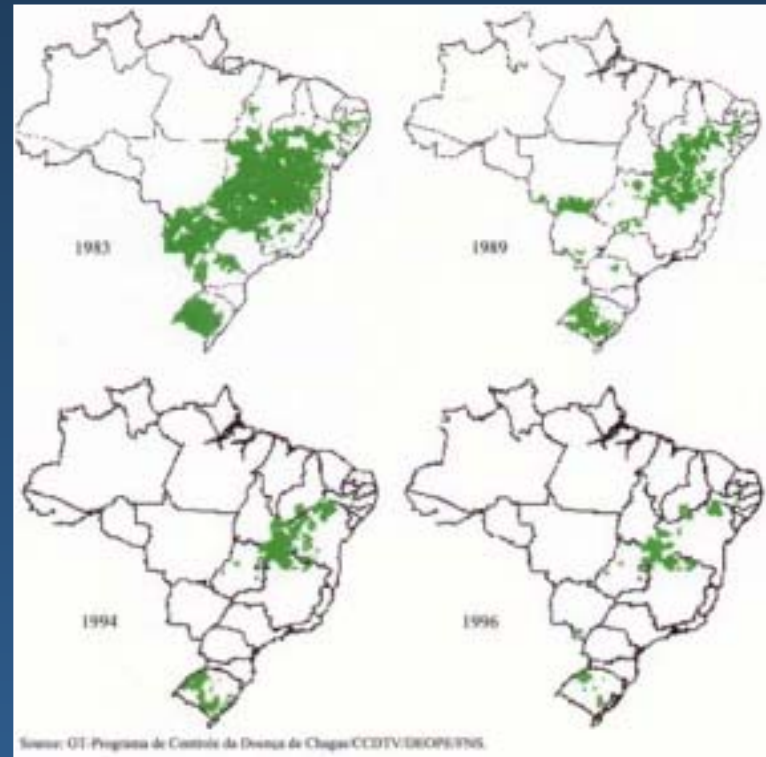
1975/1983:

711 counties in 12 states

1998:

102 counties in 7 states

CHAGAS DISEASE CONTROL
PROGRAM
(NATIONAL HEALTH FOUNDATION
BRAZIL)



**NUMBER OF MAJOR SPECIES OF TRIATOMINAE
CAPTURED AND THE PERCENTAGE OF REDUCTION,
BRAZIL, 1983 AND 1997**
(Silveira & Vinhaes 1999).

SPECIES	YEARS		
	1983	1997	%
<i>Triatoma infestans</i>	162,136	1,080	-99.3
<i>Panstrongylus megistus</i>	149,248	4,104	-97.2
<i>Triatoma pseudomaculata</i>	125,634	48,145	-61.6
<i>Triatoma sordida</i>	189,260	81,970	-56.6
<i>Triatoma brasiliensis</i>	99,845	55,513	-44.4

SPECIAL ATTENTION IS REQUIRED WITH *T. BRASILIENSIS*:

- REDUCED ONLY BY **44%** AFTER CONTROL MEASURES;
- PRESENTS A **WIDESPREAD GEOGRAPHIC RANGE**;
- IT CAN BE FOUND IN **NATURAL** AND **ARTIFICIAL** ECOTOPES;
- CAN BE FOUND **NATURALLY INFECTED BY *T. CRUZI***;
- PRESENTS **ECLECTIC FEEDING** PATTERNS;
- CAN BE FOUND IN **HIGH POPULATION DENSITIES**;
- PRESENTS AT LEAST **FOUR DISTINCT POPULATIONS**.

GENERAL ASPECT OF THE FOUR DISTINCT *T. BRASILIENSIS* POPULATIONS.

ACCORDING TO:
COSTA *et al* (1997)
COSTA *et al* (1997)
COSTA *et al* (1998)
COSTA *et al* (2000)
COSTA *et al* (2001)



brasiliensis



melanica

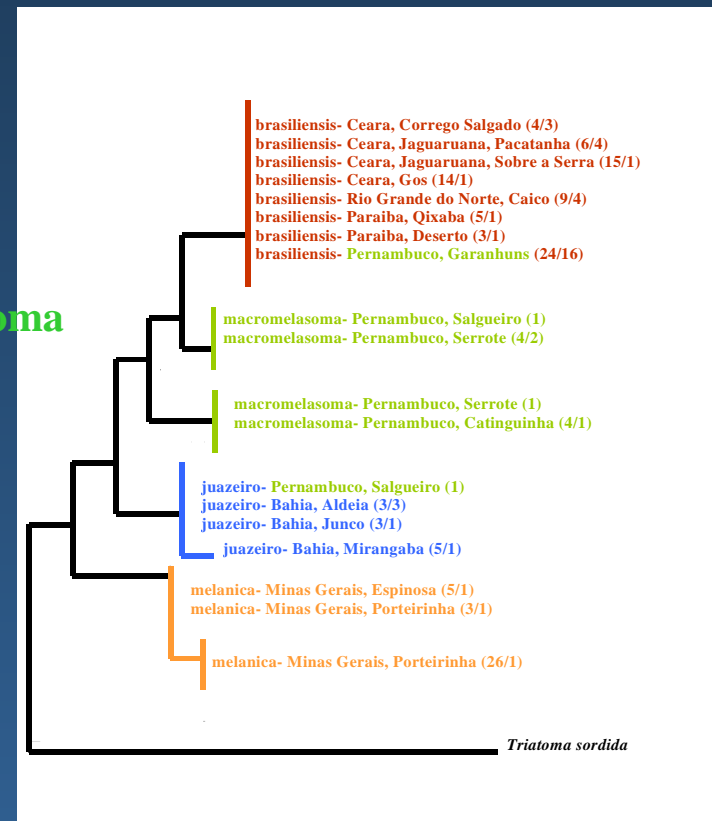


macromelasoma



juazeiro

PHYLOGENETIC TREE INFERRED FOR 136 SAMPLES OF FOUR *T. BRASILIENSIS* POPULATIONS (BRASILIENSIS, MACROMELASOMA, JUAZEIRO AND MELANICA) CONSTRUCTED BASED ON 510 BP SEQUENCES OF THE CYTOCHROME B GENE, ANALYZED ACCORDING TO THE NEIGHBOR-JOINING METHOD. NUMBERS IN PARENTHESIS ARE NUMBER OF SPECIMENS ANALYZED/NUMBER OF HAPLOTYPES. (Costa et al 2001)



QUESTIONS

A CONSIDERABLE DEBATE EXISTS REGARDING THE NATURE OF THESE DIFFERENCES: DO THE VARIOUS *T. BRASILIENSIS* POPULATIONS SIMPLY REPRESENT MORPHS OF ONE BROADLY DISTRIBUTED SPECIES, OR DO THEY REPRESENT DISTINCT BIOLOGICAL ENTITIES THAT COULD HAVE DISTINCT ROLES IN ECOLOGICAL COMMUNITIES AND IN DISEASE TRANSMISSION CYCLES?

MATERIALS & METHODS

- **T**HE *T. BRASILIENSIS* OCCURRENCE DATA SET WAS COLLECTED BY THE FUNDAÇÃO NACIONAL DE SAÚDE OF BRAZIL DURING 1997-1999 AS A PART OF THE NATIONAL CONTROL PROGRAM.
- **F**OR THIS STUDY, ALL MUNICIPALITIES IN WHICH *T. BRASILIENSIS* WAS COLLECTED INSIDE DOMICILES WERE CONSIDERED, FOR A TOTAL OF 111 UNIQUE LOCALITY SAMPLES.

MATERIALS & METHODS

-THE FOUR DIFFERENT *T. BRASILIENSIS* POPULATIONS WERE CHARACTERIZED ACCORDING TO THEIR GEOGRAPHIC DISTRIBUTION, AND COLORATION PATTERNS;
IN ALL, SAMPLE SIZES FOR THE FOUR POPULATIONS WERE **43 FOR BRASILIENSIS**, **7 FOR MELANICA**, **14 FOR JUAZEIRO**, AND **4 FOR MACROMELASOMA**..

MATERIALS & METHODS

- **DISTRIBUTIONAL MODELING-** ECOLOGICAL NICHES AND POTENTIAL GEOGRAPHIC DISTRIBUTIONS WERE MODELED USING THE ***GENETIC ALGORITHM FOR RULE-SET PREDICTION (GARP)***.

MATERIALS & METHODS

- **GARP** RELATES ECOLOGICAL CHARACTERISTICS OF KNOWN OCCURRENCE POINTS TO THOSE OF POINTS RANDOMLY SAMPLED FROM THE REST OF THE STUDY REGION, SEEKING TO DEVELOP A SERIES OF DECISION RULES THAT BEST SUMMARIZE THOSE FACTORS ASSOCIATED WITH THE SPECIES' PRESENCE.

MATERIALS & METHODS

- **GIS DATA COVERAGE- 22 DATA LAYERS WERE USED:** ELEVATION, SLOPE, ASPECTS OF CLIMATE INCLUDING ANNUAL MEAN (1960-1990) CLOUD COVER, DAILY TEMPERATURE RANGE, MINIMUM AND MAXIMUM ANNUAL PRECIPITATION, VAPOR PRESSURE, WET DAYS, AND WIND SPEED, PLUS MONTHLY DATA (JANUARY AND JULY) FOR PRECIPITATION AND THE TWO TEMPERATURE MEASURES, AND TREE COVER AND LAND USE/LAND COVER

(<http://edcdaac.usgs.gov/glcc/glcc.html>).

(<http://edcdaac.usgs.gov/gtopo30/hydro/>);

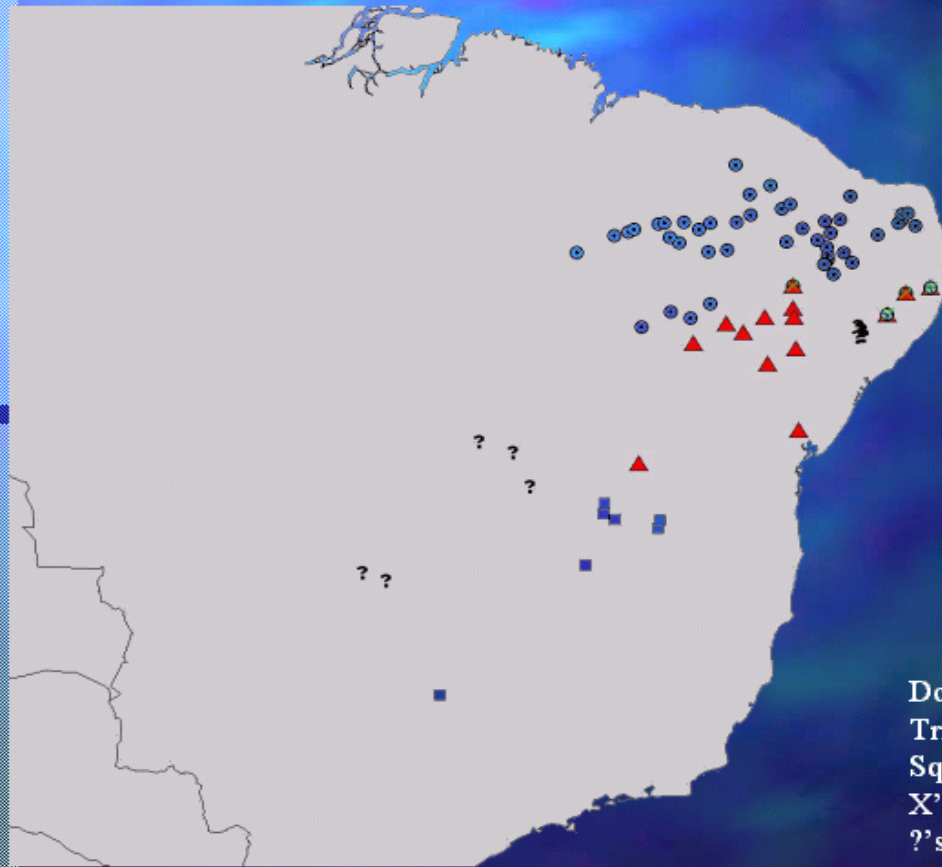
(<http://www.ipcc.ch/>);

MATERIALS & METHODS

- **E**COLOGICAL DIFFERENTIATION WAS MEASURED AS THE ABILITY OR INABILITY OF EACH POPULATION'S MODEL TO PREDICT THE KNOWN POINTS FOR EACH OTHER POPULATION; THE RESULTING MATRIX OF ECOLOGICAL **SIMILARITY OR DIFFERENTIATION SUMMARIZES PATTERNS OF DIFFERENTIATION IN ECOLOGICAL SPACE.**

RESULTS

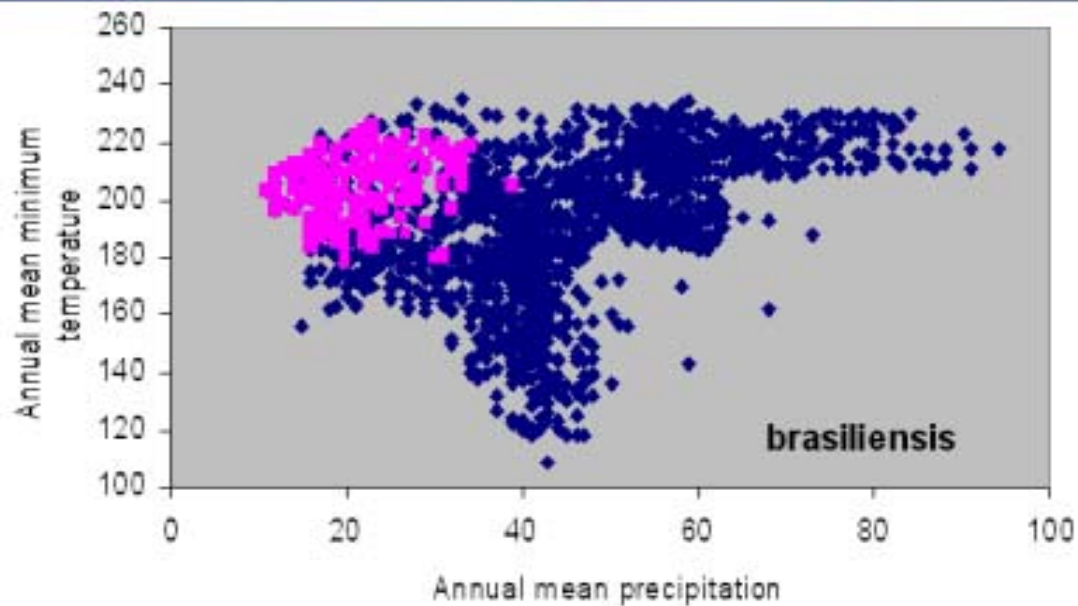
Distribution of points for each population



Dotted circles = brasiliensis
Triangles = juazeiro
Squares = melanica
X's = macromelasoma
?'s = undetermined

RESULTS

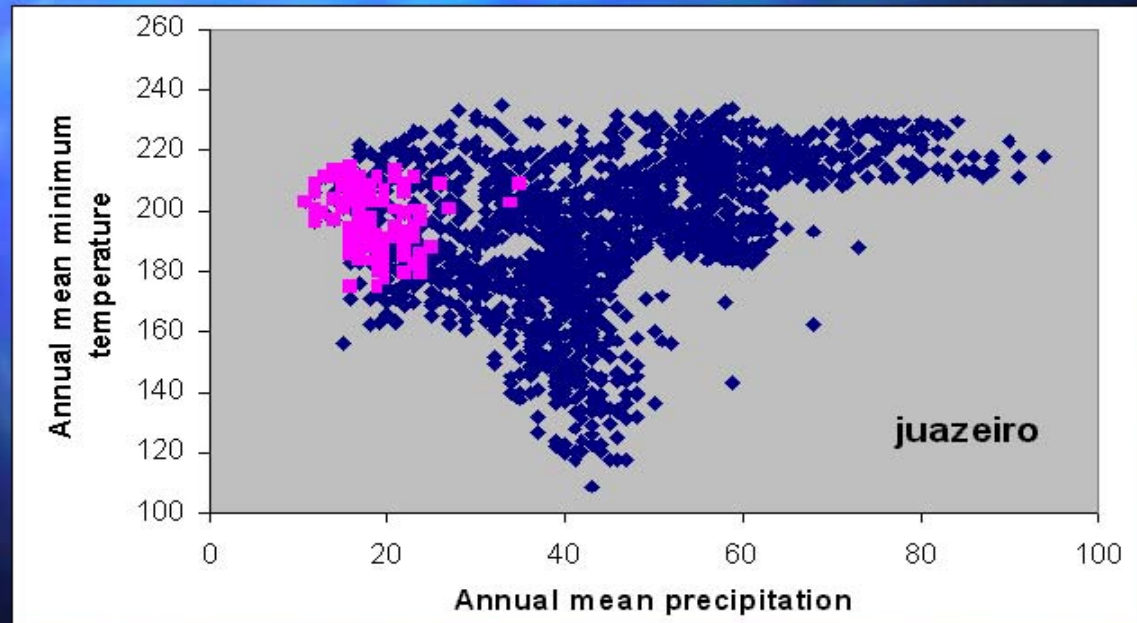
Niche diagram for brasiliensis



Environmental combinations available in northeastern Brasil and adjacent areas are shown in blue, whereas those potentially inhabited by brasiliensis are shown in pink

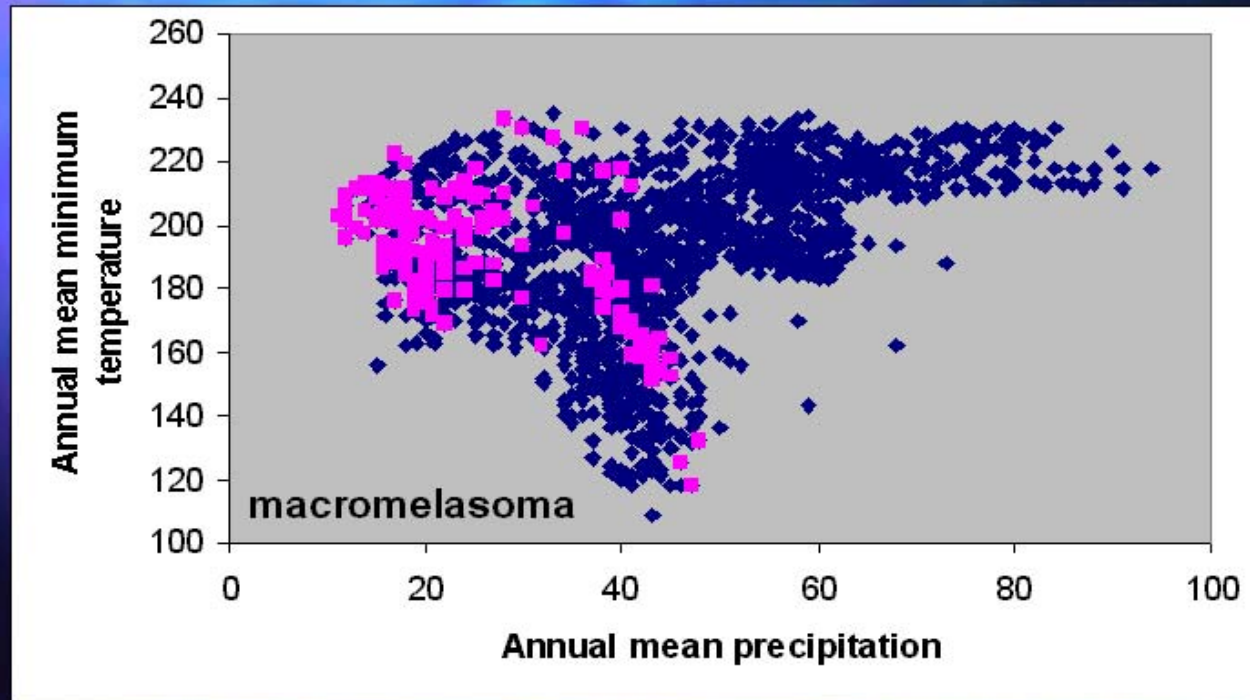
RESULTS

Niche diagram for juazeiro



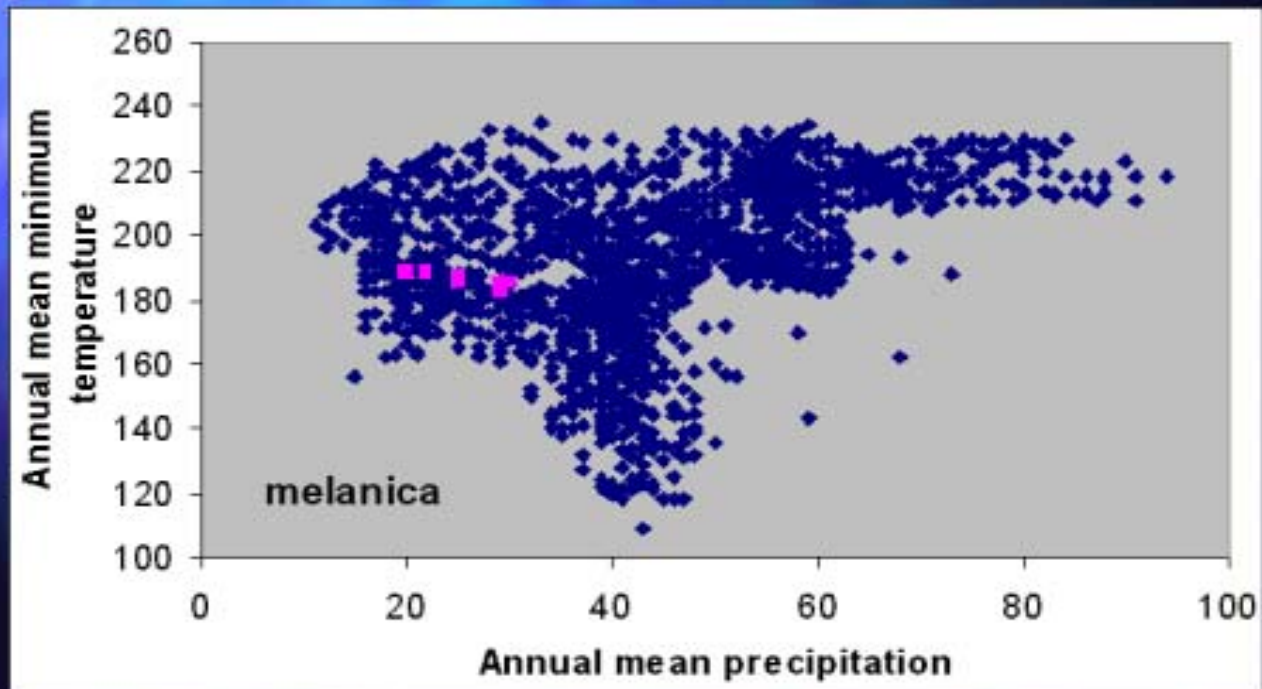
RESULTS

Niche diagram for macromelasoma



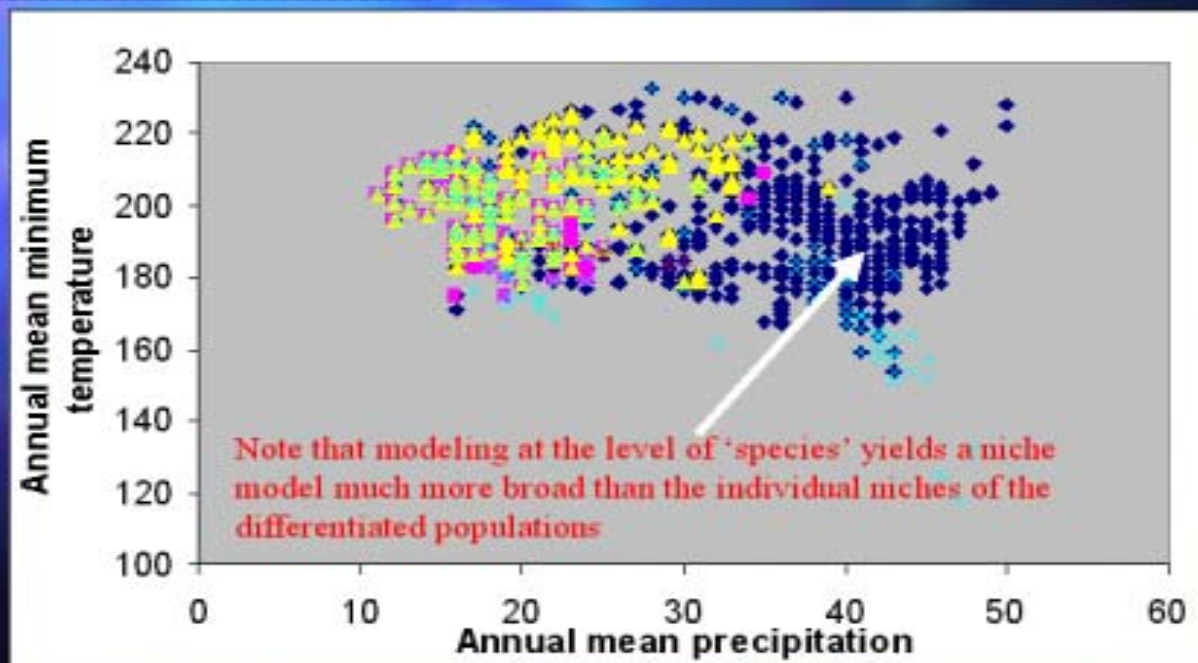
RESULTS

Niche diagram for melanica



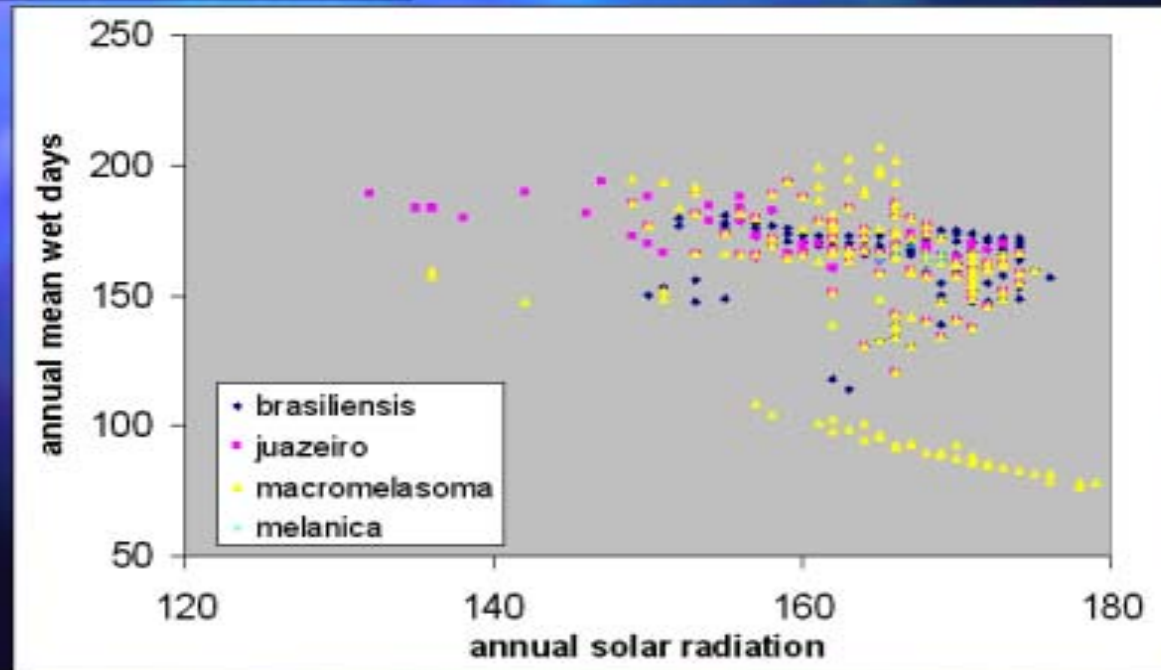
RESULTS

Niche comparison of species analyzed all together versus analysis at the level of populations



RESULTS

Are the four populations part of a cline related to climate?



RESULTS

Ecological similarity matrix among populations, based on the ability of the model for one population to predict the distribution of another

		Predictor			
		bras	mela	macro	juaz
Predicted	bras	0.98	0.00	0.44	0.51
	mela	0.38	0.85	0.10	0.21
	macro	0.87	0.00	1.00	0.87
	juaz	0.87	0.00	0.76	0.93

Note the asymmetry, in which *brasiliensis* predicts other populations well, but is predicted by them only poorly. This suggests that its ecological niche is broader, and includes those of the other populations

Note the extreme differentiation of *melanica*, with very little ability to predict or be predicted by other populations

Note that these patterns of ecological similarity coincide almost exactly with the patterns of similarity in genetic characters that was documented by Costa et al. (1998, 2001).

CONCLUSIONS

- THE **ECOLOGICAL MATRIX** GENERATED FROM THE ECOLOGICAL NICHE MODELS **CORRESPONDS** VERY CLOSELY WITH THE SIMILAR IN **MOLECULAR SETS**.
- THIS SUGGESTS THAT *T. BRASILIENSIS* IS A **COMPLEX OF DISTINCT POPULATIONS** AT VARIOUS POINTS IN THE PROCESS OF SPECIATION.

CONCLUSIONS

-THE MELANICA POPULATION IS THE MOST DIFFERENTIATED.

-THE LACK OF CORRELATION OBSERVED BETWEEN CLIMATIC GRADIENTS AND PHENOTYPIC DIFFERENCES OF THE FOUR POPULATIONS SUPPORTS THE IDEA THAT THE CHARACTERISTICS COLORATION PATTERNS OF EACH POPULATION ARE GENETICALLY BASED.

EPIDEMIOLOGIC IMPLICATIONS

- THIS IS THE FIRST APPLICATION OF GARP IN THE FIELD OF EPIDEMIOLOGY AND DISEASE TRANSMISSION;
- THIS TOOL CAN ALSO BE APPLIED TO BETTER UNDERSTAND VECTOR SPECIES DISTRIBUTION OF SEVERAL OTHER INFECTIOUS DISEASES;

EPIDEMIOLOGIC IMPLICATIONS

- THE CHAGAS DISEASE CONTROL PROGRAM OF NHF (BRAZIL) HAS SHOWN THAT **RAPID ECOLOGICAL SHIFTS CAN OCCUR IN RESPONSE TO CONTROL MEASURES, DEMANDING CONSTANT ENTOMOLOGICAL SURVEILLANCE;**
- **THE APPLICATION OF THIS TOOL WOULD BE VERY USEFUL TO ASSESS IMPORTANT QUESTIONS IN THE VECTOR BORNE DISEASES ECOLOGY AND/OR EPIDEMIOLOGY.**

EPIDEMIOLOGIC IMPLICATIONS

- **I**N TERMS OF DISPERSION POTENTIAL, IT SEEMS THAT SPECIAL ATTENTION IS REQUIRED TO THE, **BRASILIENSIS POPULATION**. ITS HIGHER GENETIC VARIABILITY ALREADY STUDIED ASSOCIATED TO THE ITS BROADEN ECOLOGIC DIMENSIONS SUGGEST THAT **THIS POPULATION IS ALSO THE MOST ABLE TO INVAD**E NEW AREAS, AND TO DEVELOP INSECTICIDE RESISTANCE.

EPIDEMIOLOGIC IMPLICATIONS

- **B**ECAUSE THE **MELANICA POPULATION** IS FOUND ONLY IN NATURAL ENVIRONMENTS, AND PRESENTS A VERY REDUCED ECOLOGIC NICHE MODEL, IT CAN BE CONSIDERED THE LESS IMPORTANT IN EPIDEMIOLOGIC ASPECTS, AND ALSO THE **LESS CAPABLE TO INVADE NEW ECOTOPES OR TO WIDE SPREAD ITS GEOGRAPHIC DISTRIBUTION.**