The distribution and ecology of larval malarial mosquitoes in Chapare Valley, Bolivia

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Introduction

Malaria is an important public problem, affecting approximately 270-488 million people and killing 1-3 million people each year (Target, 1991, Savage et al, 1990); nearly 15 million of these cases occur in tropical America (Sturchler, 1989). Although the vector species of malaria are well known in Africa and some regions in Asia, significantly less is known about the transmission of the disease in the Neotropics. Unlike in Africa, where two or three species are responsible for most transmission throughout the continent, the epidemiology of malaria in the Neotropics is more complex due, in part, to the diversity of the potential vectors (Audho et al, 1995) and complex ecological history (Vuilleumier, 1971). Thus one of the major obstacles in studies attempting to determine the identity, behavior and ecology of primary vectors has been the great difficulty in distinguishing species. The Chapare Valley in Bolivia is of particular interest for examining the epidemilogy of malaria since it exemplifies the changing nature of tropical rainforest areas of South America. Much of the Valley is now disturbed, is inhabited by subsistence farmers, is a patchwork of secondary forest and agricultural lands, and has a large proportion of migrant workers. Human disturbed rainforests typically have as much as a five-fold increase in anopheline densities over undisturbed forests (Tadei et al, 1998) and probably affect species diversity too. The Chapare Valley thus offers a good model system for examining and understanding vector dynamics in a region of the Neotropics where there is a great diversity of potential vector species and ecological habitats, concomitant with the effects of human activity in the ecology of a rainforest.

Purpose of the study

The purpose of the study is to address the ecological differentiation of anopheline species at the level of breeding sites in a valley region where species diversity is high and the ecology of the area is complex. We hypothesize that environmental variables predict the distribution patterns of larval mosquitoes in the Chapare Valley. The specific objectives include:
- determination of malaria mosquito species and their distributions in breeding habitats.
- description of limnological and altitudinal profiles of breeding sites and correlations with species distribution patterns.

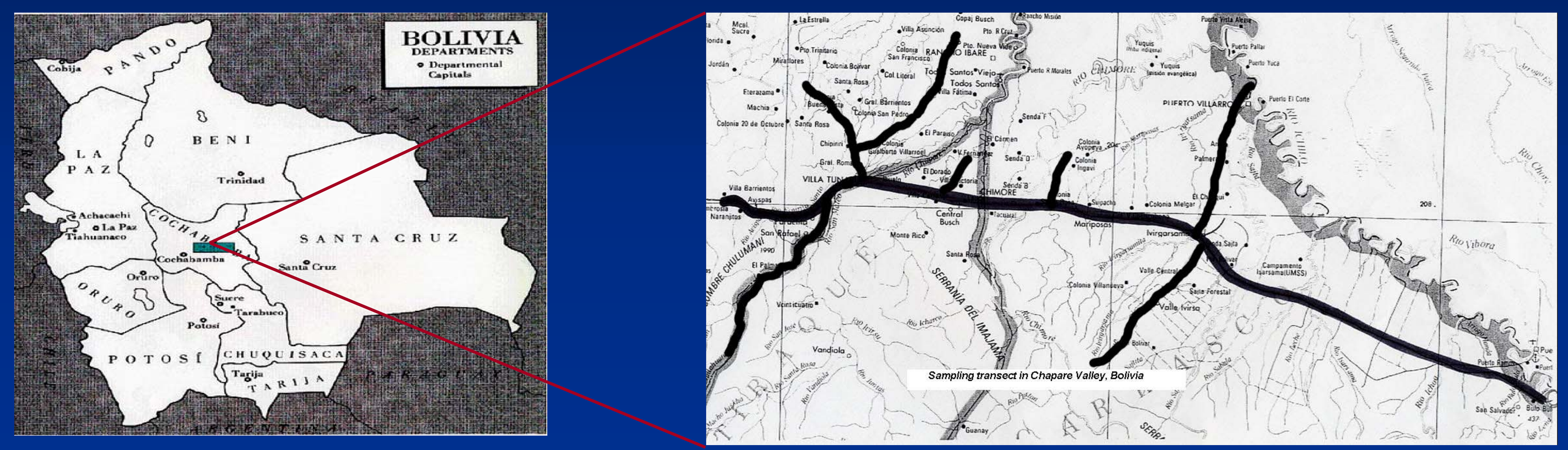
Methodology

- *Sampling at breeding sites :* 56 anopheline breeding sites were sampled for mosquito larvae and water quality parameters. Measures of water quality included pH, TDS, conductivity, turbidity, temperature, NO3, NH4-N, COD, PO4, volatile solids, suspended solids and fixed solids using standard limnological methods. Elevation of each site was taken using an altimeter.

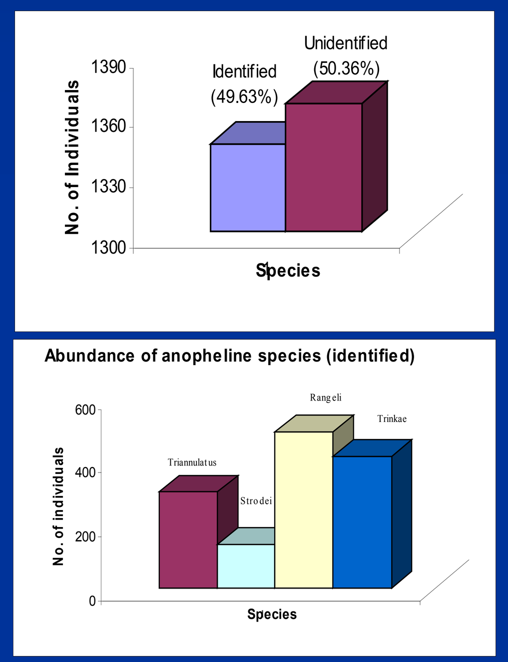
- *Polymerase Chain Reaction (PCR):* 50 random larvae from each site were amplified using a multiplex PCR that identified four species. Amplification products for these species were at least 40bp different in length and thus easily resolved on 2% agarose gels.

- *Statistical analyses* : Relationships among environmental variables and the occurrence of the mosquito taxa were investigated using Principal Component Analysis (PCA). A series of correlations were completed for each species and the PCA factor. One way Anova was used to relate species distribution to elevation.

Study site



Results



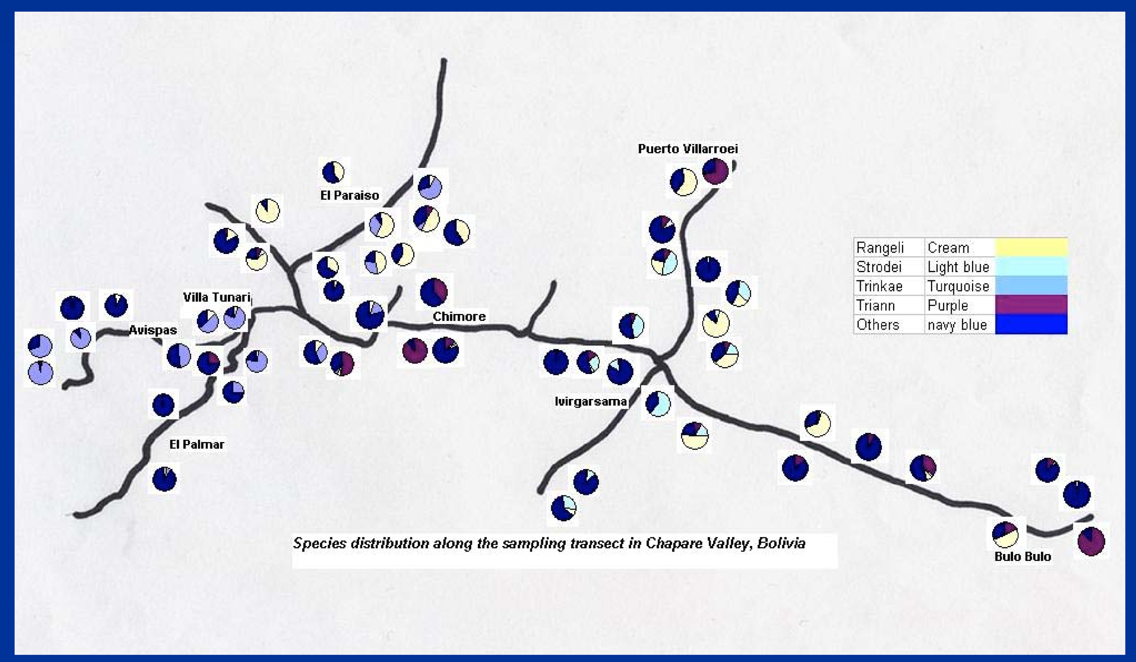
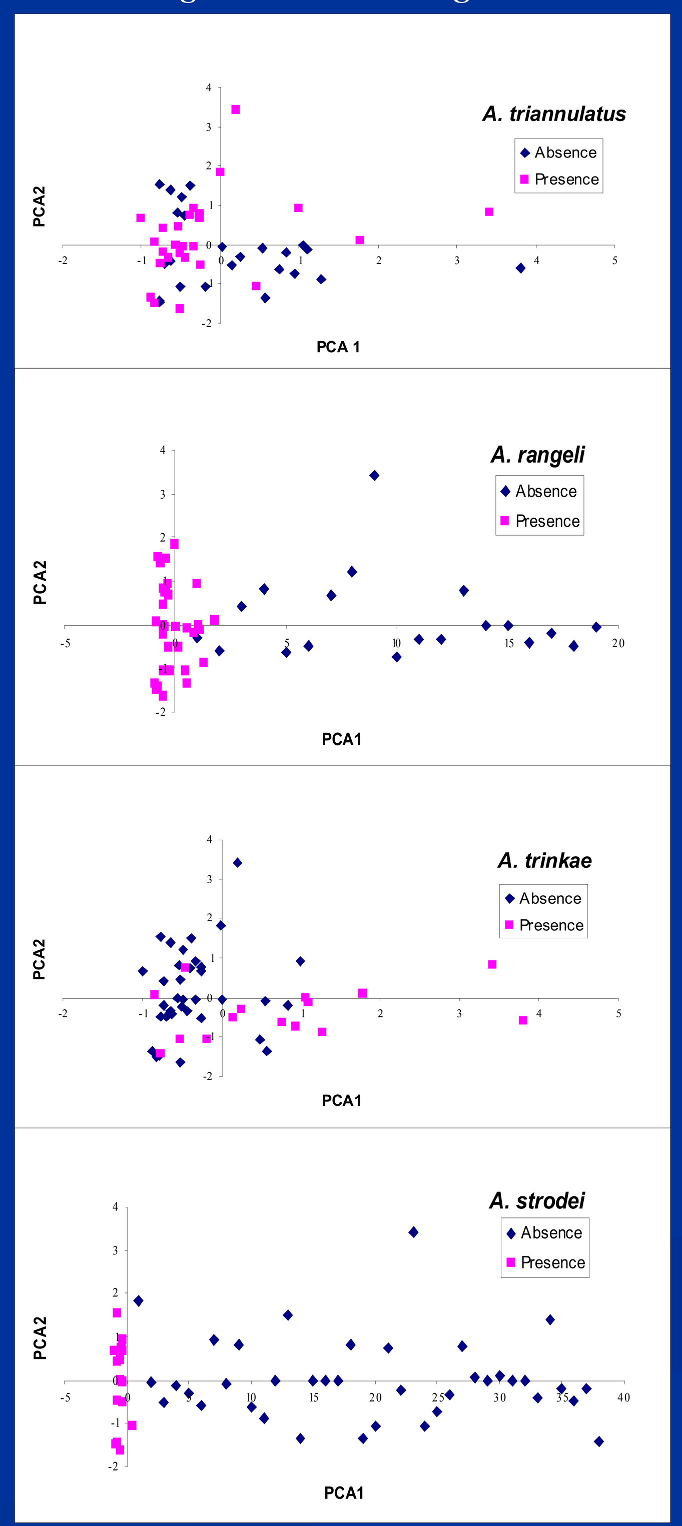


Fig. PCA of Presence/Absence of species along the environment gradient



Pearson correlation of limnological variables with PCA factors

	PCA1	Corr.	PCA2	Corr.		PCA1	Corr.	PCA2	Corr.
DO	.927		.004	+ve	Conductivity	<.001	+ve	.709	
Turbidity	.015	-ve	<.001	+ve	PO4	.668		.022	-ve
NO3	.229		<.001	-ve	Tot. solids	<.001	+ve	.573	
COD	.316		.491		Dis. Solids	<.001	+ve	.626	
NH4-N	.931		.064		Sus. Solids	.165		<.001	+ve
pH	<.001	+ve	.040	-ve	Volatile solids	<.001	+ve	.014	+ve
TDS	<.001	+ve	.637		Fixed solids	<.001	+ve	.789	

Significance at 0.05 level (2 tailed), alpha=0.01

One way Anova (Species vs Elevation)

Species	Significance
Triannulatus	0.654
Rangeli	0.034
Strodei	0.072
Trinkae	0.007

Significance at 0.05 level (2 tailed), alpha=0.01

Pearson correlation of species with limnological variables

	Triann	*Rangeli*	*Strodei*	*Trinkae*		*Triann*	*Rangeli*	*Strodei*	*Trinkae*
DO	.029	.689	.958	.785	Conductivity	.085	.873	.021	<.001
Turbidity	.195	.332	.934	.014	PO4	.408	.498	.408	.379
NO3	.755	.542	.237	.782	Tot. solids	.247	.955	.247	<.001
COD	.860	.480	.001	.647	Dis. Solids	.076	.923	.043	<.001
NH4-N	.418	.328	.586	.893	Sus. Solids	.002	.824	.468	.965
pH	<.059	.180	.028	<.001	Volatile solids	.338	.398	.077	.009
TDS	<.066	.866	.021	<.001	Fixed solids	.256	.858	.045	<.001

Significance at 0.05 level (2 tailed), alpha=0.01

Results/Discussion

Using a multiplex PRC that identified only four species of anopheline mosquitoes found in the Chapare Valley, we accounted for nearly 50% of all mosquito larvae collected from 56 aquatic breeding sites. *An. rangeli* and *An. trinkae* appear to be the most abundant species, but *An. triannulatus* is most widely dispersed. The distributions of *An. trinkae*, *An. rangeli* and *An. strodei* are limited to certain altitudinal zones, though interspecific competition cannot be ruled out as a factor in addition to other variables (e.g. limnological variables and other aspects of habitat including those that may affect adults).

Environmental variables correlated significantly with the distributions of species. DO, pH, TDS and suspended solids have a significant role in defining *Triannulatus* breeding sites. *Strodei* breeding sites had a significant relationship with COD, TDS, conductivity, pH and fixed solids. Most of the limnological variables measured have significant relationships with *Trinkae* habitat.

Understanding species distribution patterns and their relationships to environmental variables will elucidate the epidemiology of malaria in the Chapare Valley and lead to more efficient and cost effective measures of control.