Transmision de malaria en Loreto del punto de vista del vector *Anopheles darlingi*

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Habitat Segregation

An. darlingi host diversity

Insecticide Susceptibility

Behaviour

Outline

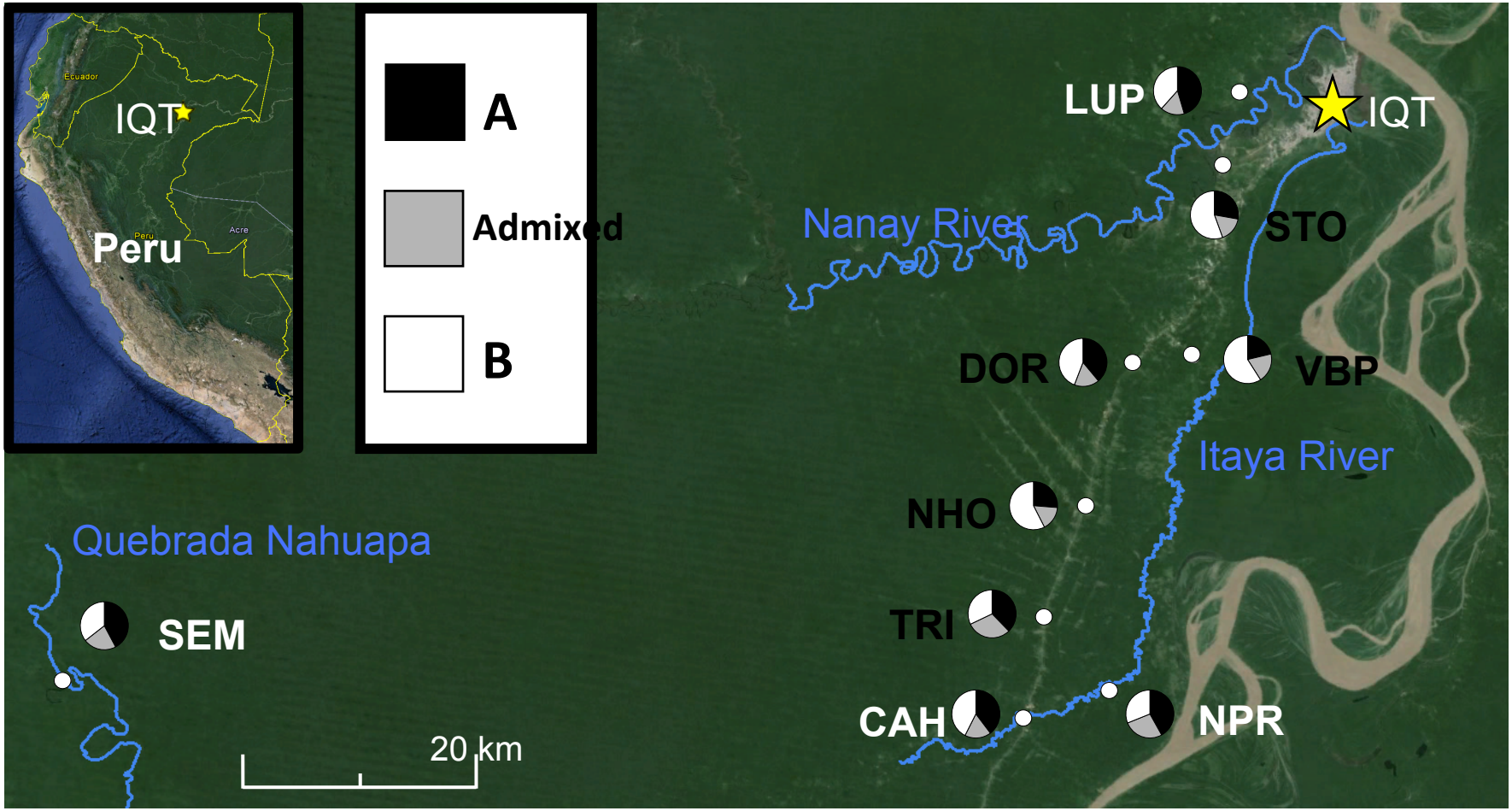
Amazonian Peru: Overall Low Malaria Transmission Landscape

- Significant overall <u>decrease</u> in malaria cases across continent since ~2005 (except recently in Venezuela)
- And in Peru…
  - 93.69% of Peruvian cases in Loreto
  - Case numbers <u>increasing</u> since 2011
  - Disease mainly focal: highways, logging, mining camps, riverine settlements. Other factors - asymptomatic people; occupational travel
  - Seasonal transmission of malaria, correlated with river levels and *An. darlingi* peak abundance
  - IR = ~ 0.7; HBR = 3.5 – 757 b/p/n; EIP = 0.3 – 2.5

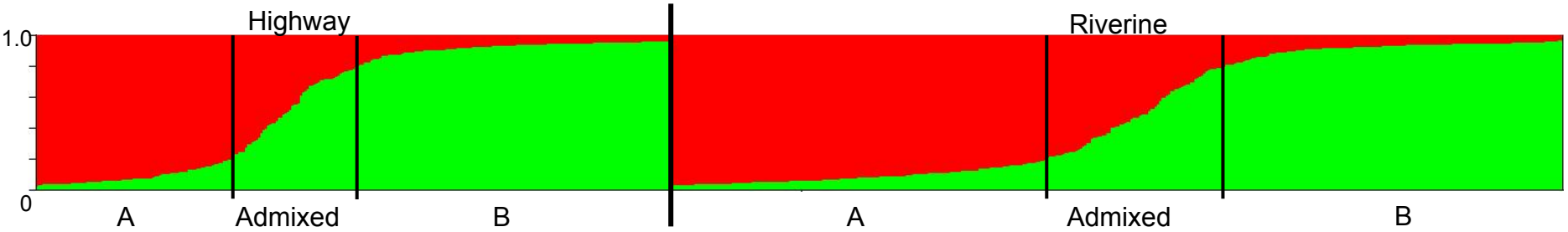
- Moreno et al 2015

Two *An. darlingi* Subpopulations A and B (Riverine/Highway)

- data from 13 microsatellite loci

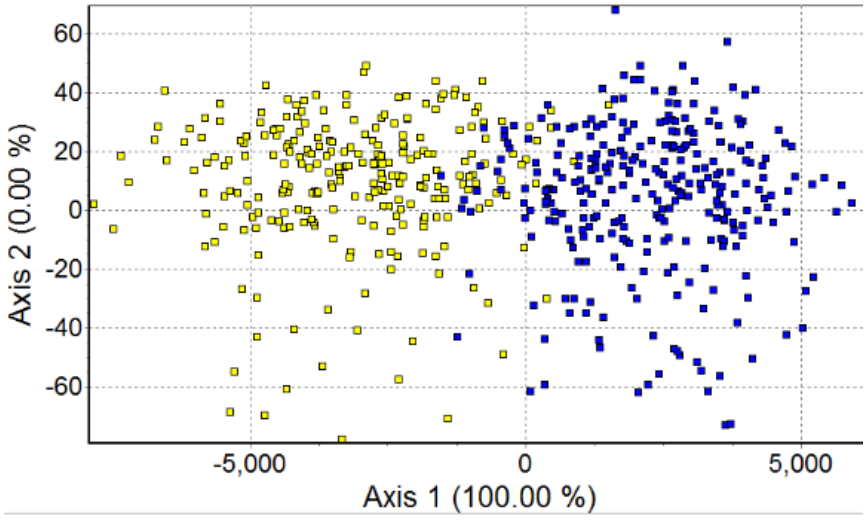


Subpop. B Significantly Overrepresented in Highway



	A	Admixed	B
Riverine	42.08%	20.05%	37.87%
Highway	30.80%	19.72%	49.48%

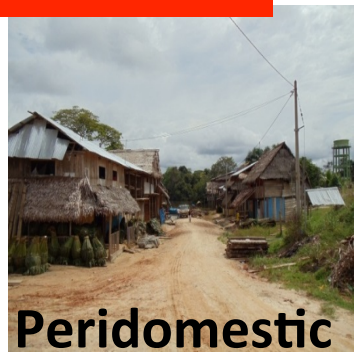
$X^2_{df=2}$= 11.0648; p<0.005



Factorial Correspondence Analysis

HBR in HW vs. Riverine at 3 Levels of Forest Cover

Forest Cover \ Habitat	Highway (Vittor)	Highway	Riverine
Peridomestic (0-20%)	6.5 (4.9, 8.0)	4.6 (0.5, 12)	53.0 (23.0, 97.0)
Chacra (20-60%)	1.7 (1.0, 2.4)	1.8 (0.0, 5.5)	5.6 (0.0, 14.5)
Forest (60-98%)	0.0 (0.0, 0.1)	0.6 (0.0, 1.5)	1.4 (0.0, 6.5)



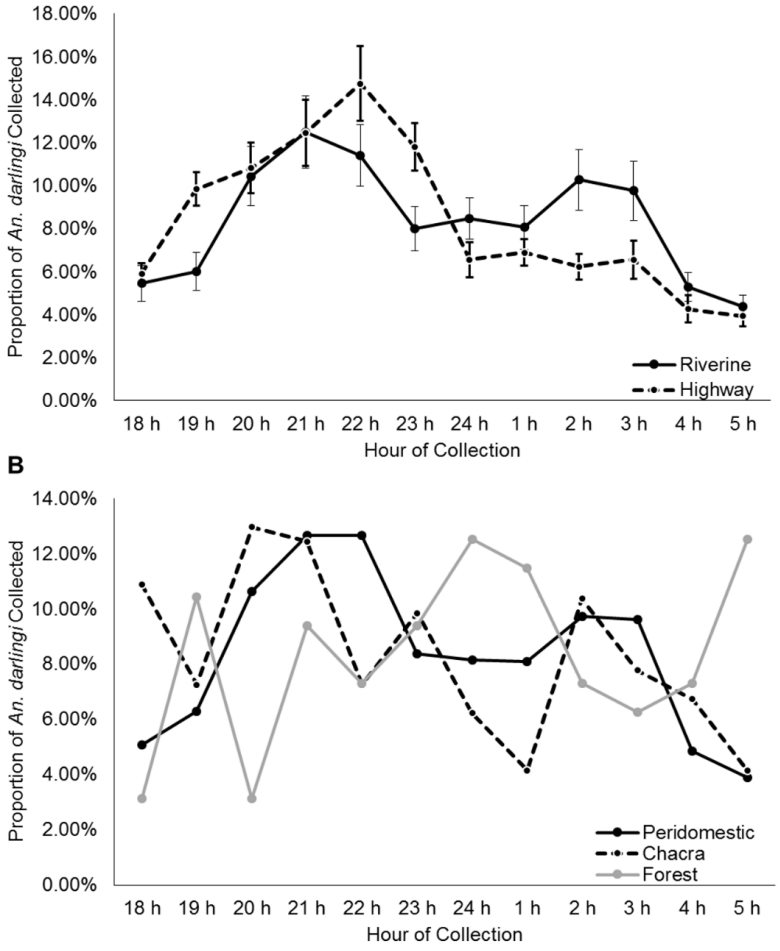
An. darlingi HBR (18:00-24:00) compared to Vittor et al. 2006.

Lainhart et al. 2015

Peak biting times differ by habitat & forest cover level

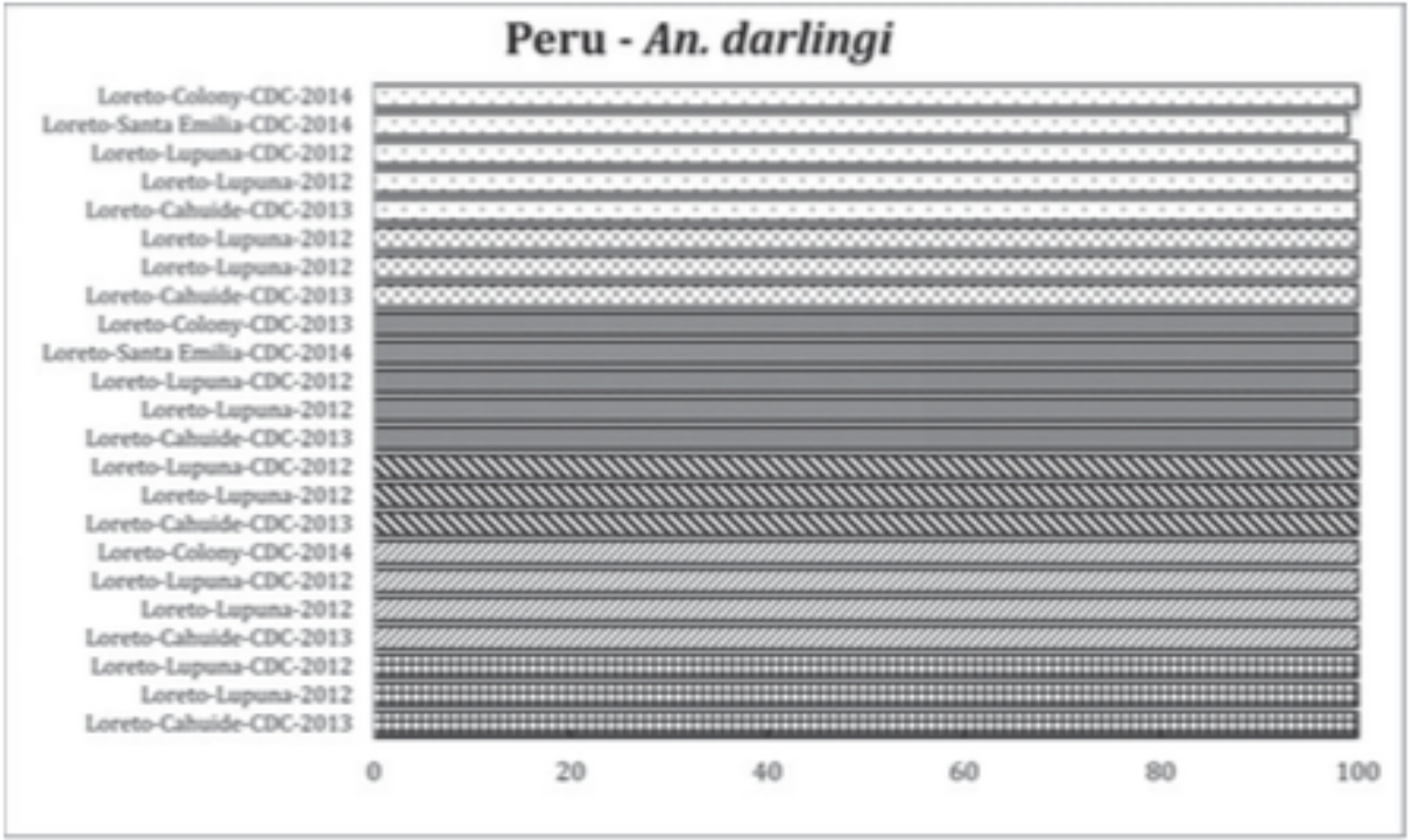
- Habitat (p = 0.001278)
  - Riverine – bimodal
  - Highway – unimodal
- Forest cover level
  - P *vs*. C: p = 0.05604
  - P *vs*. F: p = 0.02862
  - C *vs*. F: p = 0.01633

- Lainhart et al. 2015



Conclusion: ecological adaptation and different genetic signature in *An. darlingi* in anthropogenic vs. riverine habitat

Insecticide Susceptibility in *An. darlingi* from CAH, LUP, STE



- **Tested using WHO and CDC bottle bioassays against deltamethrin, lambdacyhalothrin, permethrin, malathion, fenetrothion and DDT.**

- **Tested on F1 progeny of colony, and field-collected *An. darlingi* 2012-2014**

Blood Meal Identification in *An. darlingi*

- **Human Blood Index (HBI): proportion of recently-fed mosquito vectors that have taken a human blood meal.**
- **HBI – useful to evaluate malaria control strategies (human-vector contact).**
- **Few studies exist documenting blood meal source in *An. darlingi*; none in the Peruvian Amazon.**
- **Accurate estimates of the HBI for a species depends on collecting an unbiased sample of resting, blood-fed mosquitoes.**

Blood Meal Identification Objectives

- Test barrier screens (Burkot et al. 2013) for efficiency in collecting *An. darlingi*
- Collect resting mosquitoes to estimate HBI
- Identify alternative blood meal sources and determine frequency of patent multiple blood meals within the mosquito population

Moreno *et al.*, 2017

Human Blood Index & Bloodmeal Analysis in *An. darlingi*

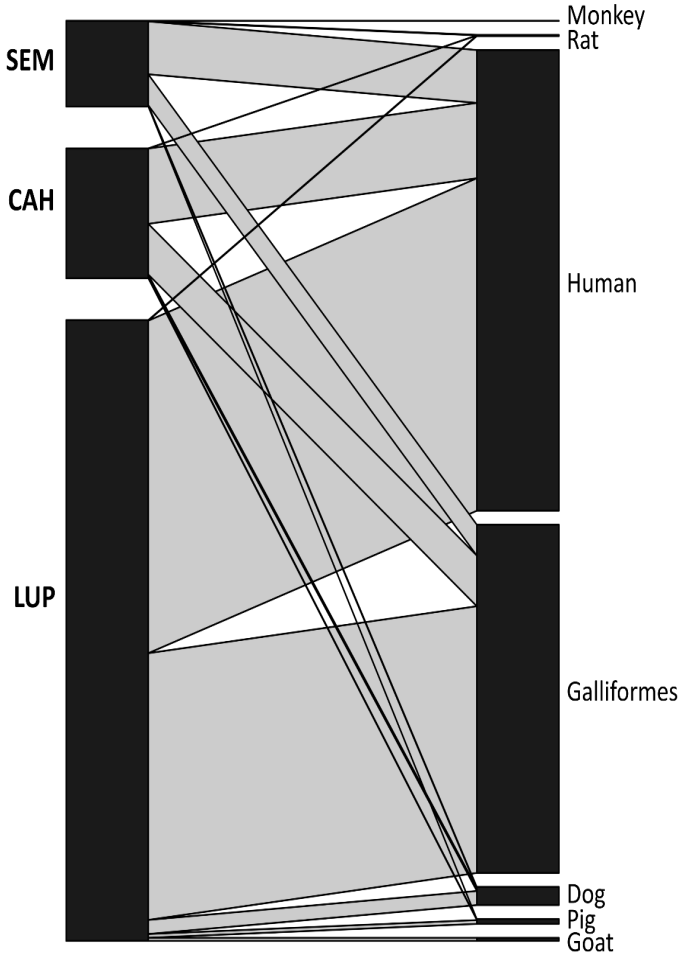
Are humans preferred host for *An. darlingi* in Iquitos region?

- **feeding behaviour quantified; bloodmeal analysis of 4,416 specimens**
- **70% single host-specific feeds; 43% humans; ~25% Galliformes**
- **1,272 patent feeds: ~90% human/ Galliformes**

- **When include host biomass (forage ratio), chickens preferred to humans**

- **pattern same among 3 villages x 3 yr; pop. structured by feeding preference?**

- **HBI range unaffected by month or location (range 0.65-0.79)**



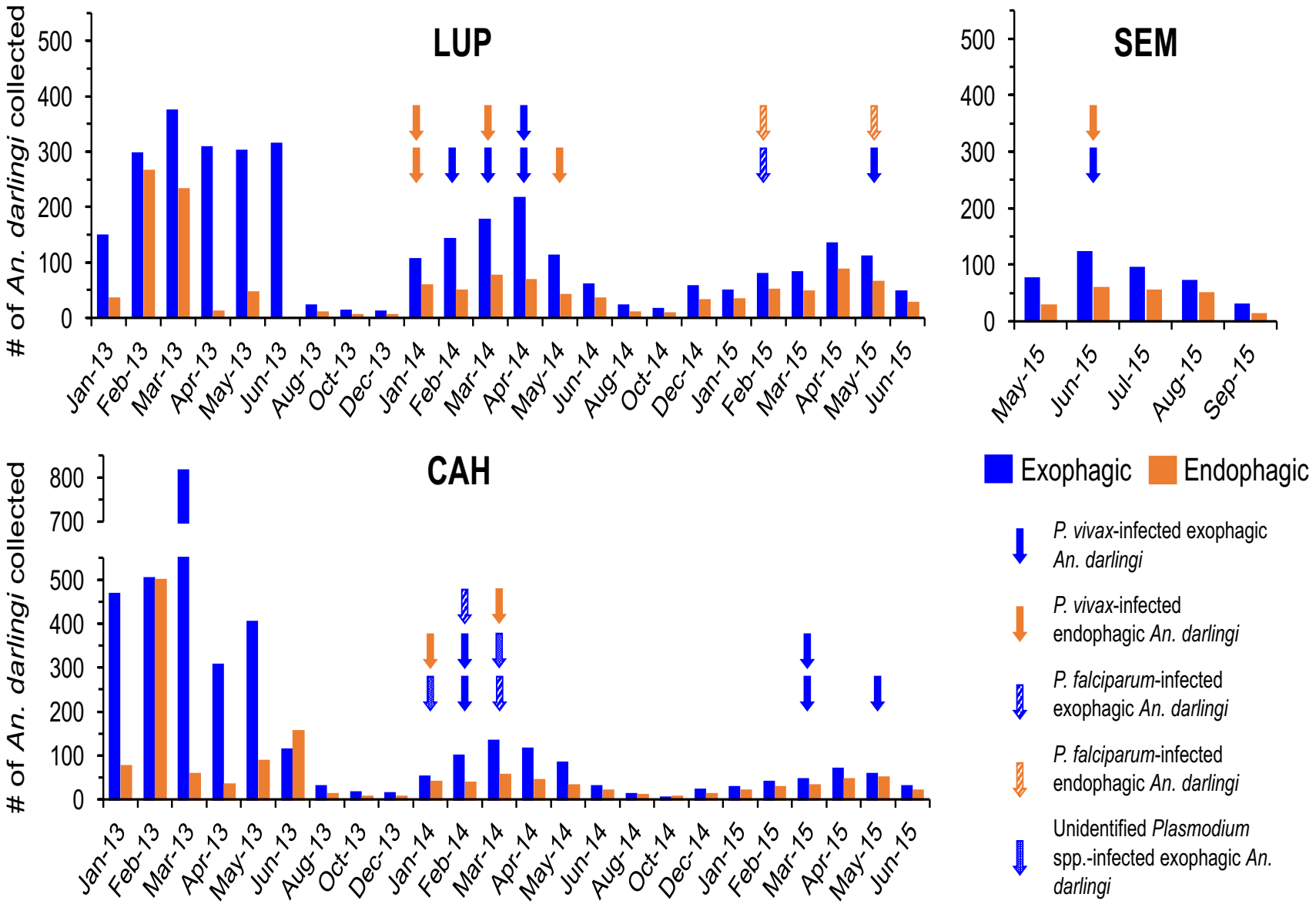
Quantitative interaction network, analysis of all bloodmeal sources, *An. darlingi* 2013-2015

Change in Biting Behaviour in *An. darlingi*, IQ 2013-2015

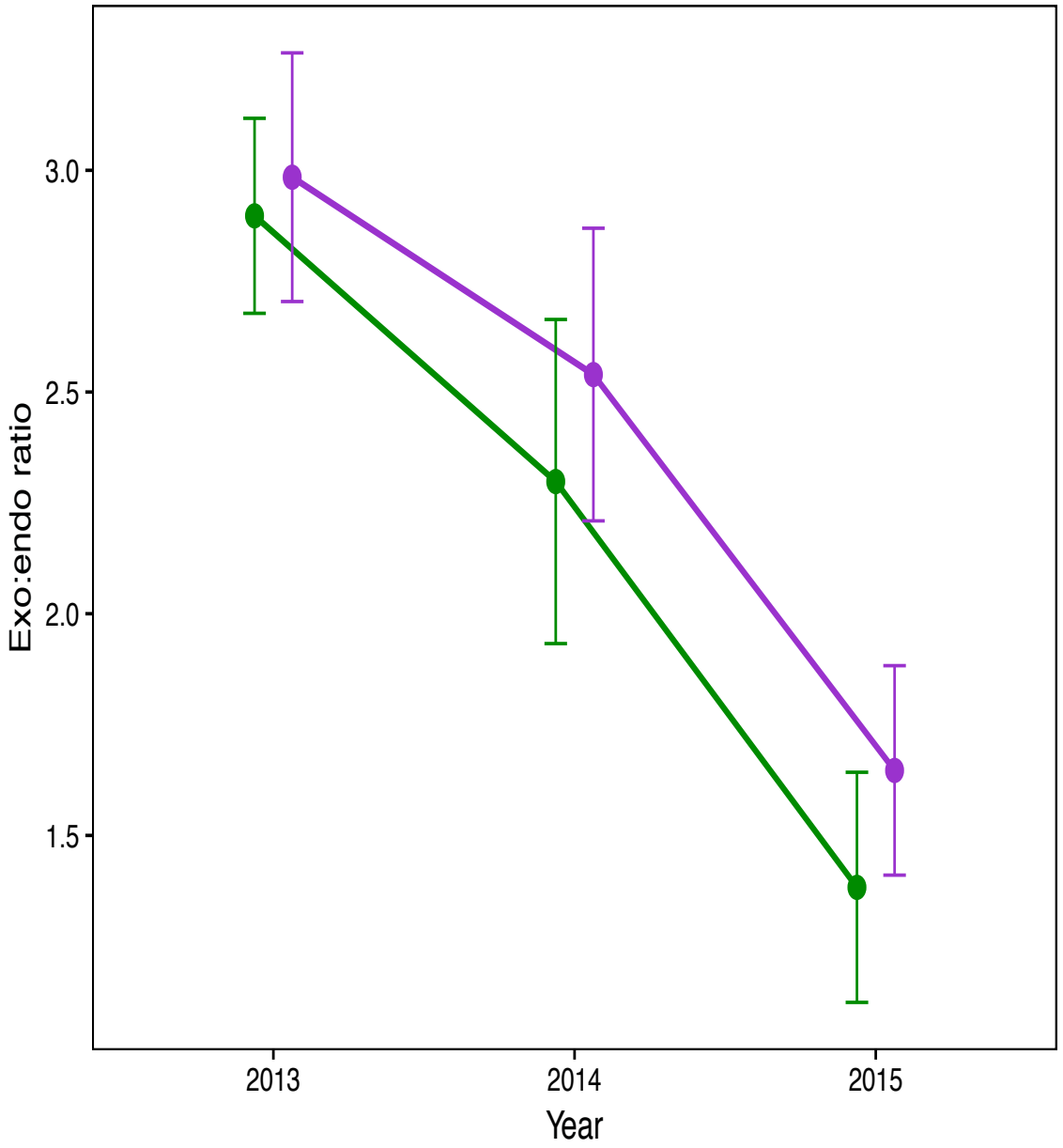
LUP, March 2016, near-peak Nanay River level

- *An. darlingi* collected by HLC monthly, January - June (rainy season)
  - 2 riverine villages (CAH, LUP)
  - 3 years (2013- 2015)
  - 2 behaviours (endophagic, exophagic)
  - 4 time periods (6-9pm, 9pm-12am, 12-3am, 3-6am)
- Analysis: negative binomial regression of abundance; treatment main effects were *Locality*, *Year*, *Indoor/Outdoor*, *Time Periods* and their interactions
- Question: Are there local temporal changes in *An. darlingi* behaviour since the end of PAMAFRO?

Results, *An. darlingi* abundance, 2013-2015



Decrease in ratio of exo:endophagy 2013-2015: Why?



1) effectiveness of LLINs distributed in 2010 likely ended late 2012-early 2013

2) IRS with 5% deltamethrin reduced ~2012 from each 3 months to zero

Conclusions and Questions

1. People in riverine communities at greater risk of transmission vs. HW
2. Evidence for ecological adaptation – increases malaria risk?
3. Is vectorial capacity equivalent between HW and riverine *darlingi*?
4. Insecticide bioassays should be conducted annually if possible
5. *An. darlingi* opportunistic and anthropophilic; depends on host biomass and availability
6. *An. darlingi* feeding behavior is plastic, rapidly adapts to local circumstances

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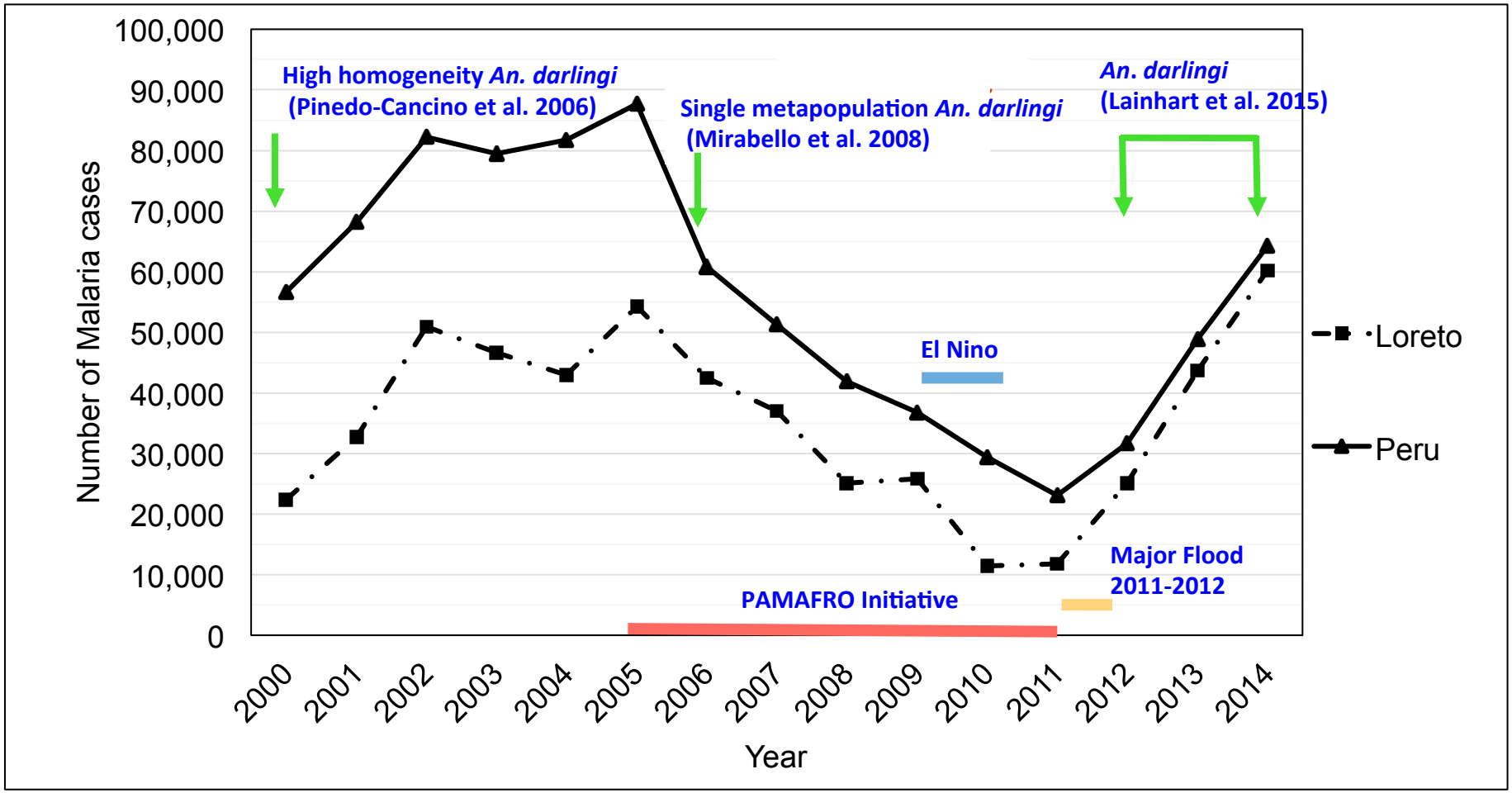
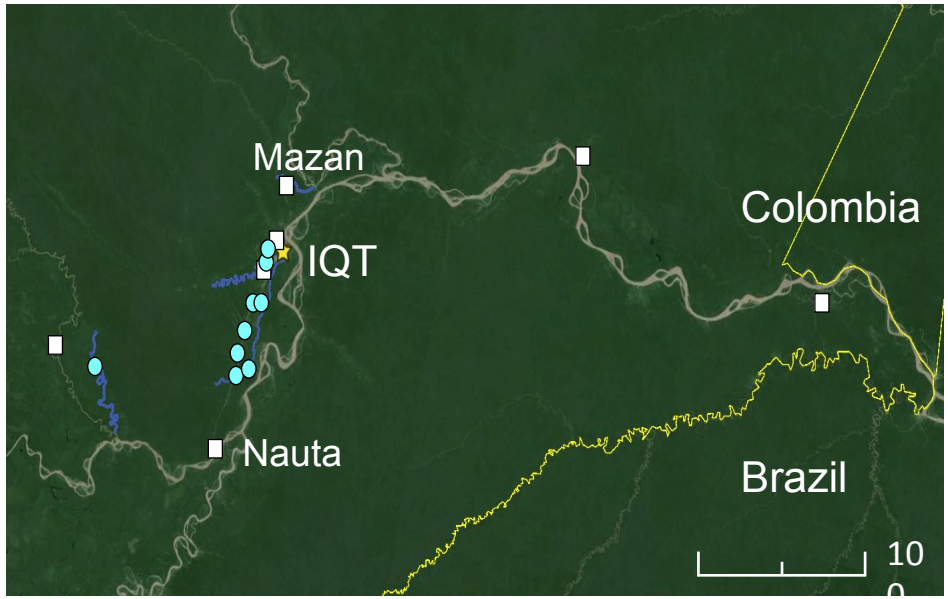
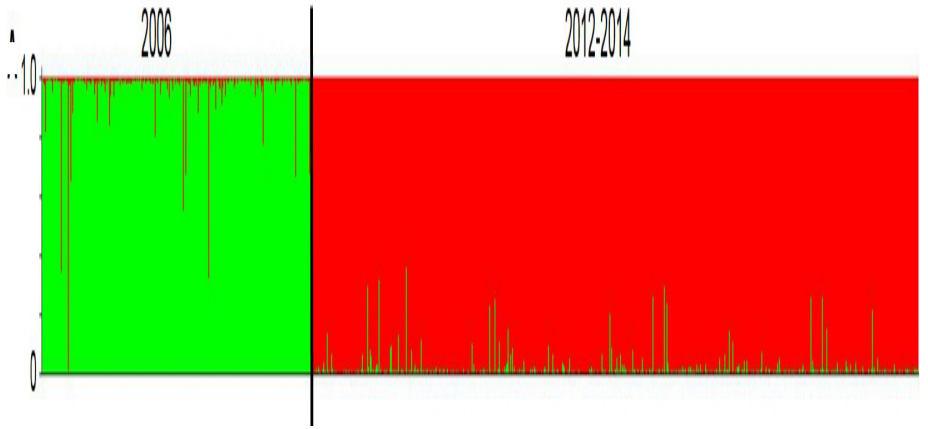
An. darlingi populations/Malaria/ PAMAFRO/El Niño



Question: Temporal change in *An. darlingi* population between 2006 and 2012-2014?

IQT Collection Sites ▫ 2006 and ○ 2012-14





- **Using microsatellites, Bayesian STRUCTURE analysis differentiates *An. darlingi* into two major clusters: (green, 2006; red, 2012-2014)**

Conclusion: Temporal change (population replacement) in *An. darlingi* 2006 – 2012-2014