Speciation Gene for Left-Right Reversal in Snails Results in Anti-Predator Adaptation

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Pareas iwasakii

Background

Speciation occurs when populations accumulate genetic differences that, upon secondary contact, cause reproductive incompatibily. How genes for reproductive incompatibilities (speciation genes) could spread in a population however, has been only poorly understood.

Puzzle in single-gene speciation


Ueshima & Asami 2003

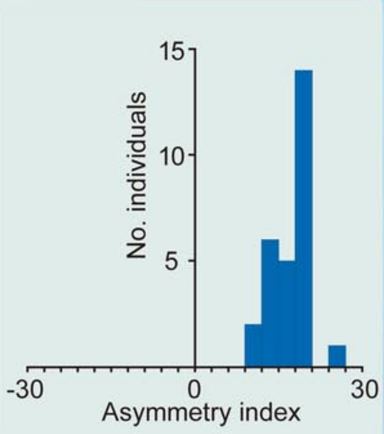
In land snails, a single gene for left–right reversal could be responsible for instant speciation, because dextral and sinistral snails have difficulty in mating.

The reversal is determined by a maternal effect of single nuclear gene(s) at a single locus. Thus, population fixation for a reversal allele could complete premating isolation, giving rise to a new species. However, the traditional two-locus speciation model predicts that a mating disadvantage for the reversal should counteract this speciation.

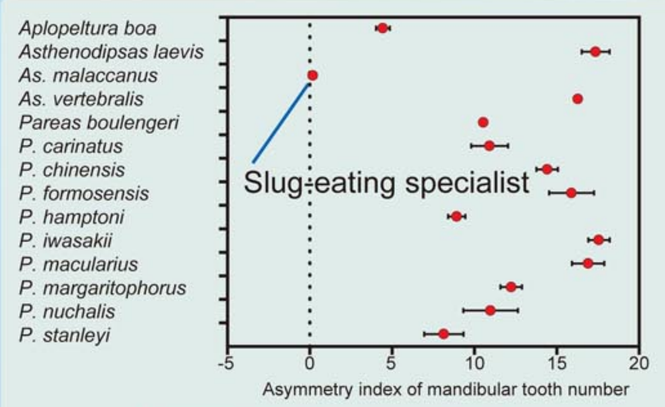
Sinistral snails survived snake predation superiorly to dextrals, especially in larger snails.

Selective agent

"Right-handed" foraging behavior of a snail-eating snake *Pareas iwasakii*.



Dentition asymmetry of *P. iwasakii*.



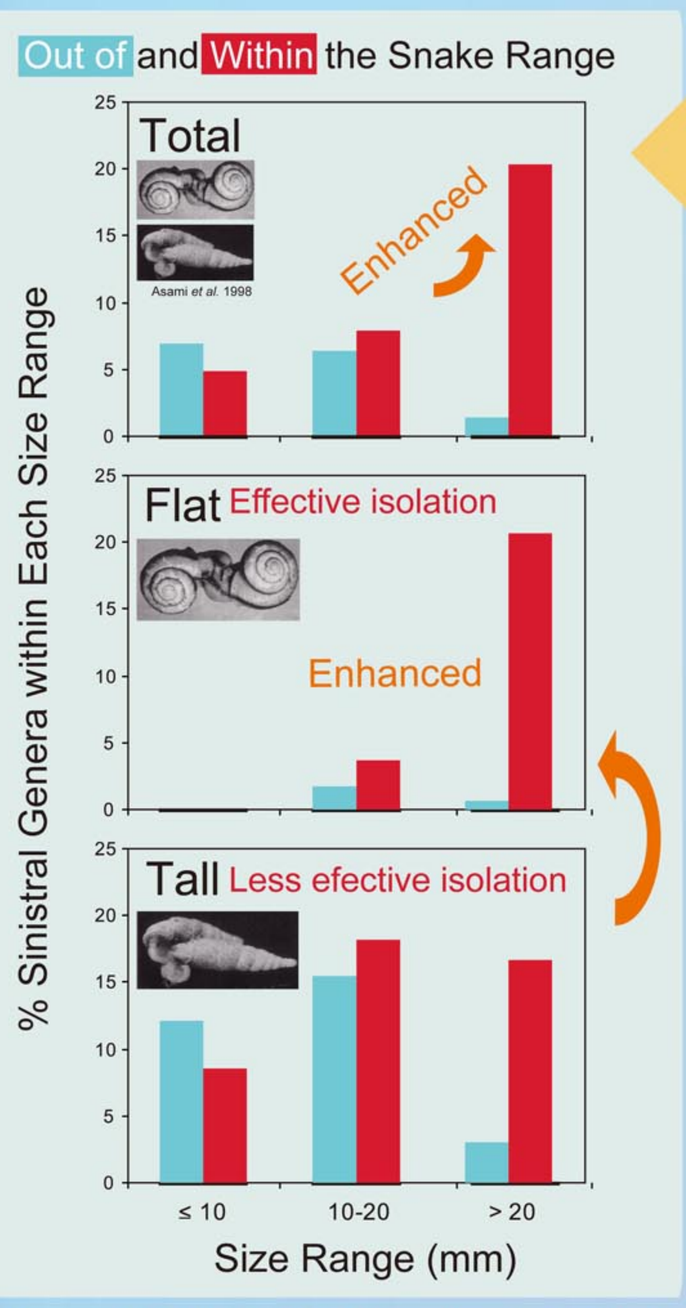
Inter-specific variation in dentition asymmetry.

The snail-eating snakes in the family Pareatidae are well adapted with laterally asymmetric foraging behavior and dentition for predation on dextral land snails. The snakes are the only selective agent that could drive single-gene speciaiton of sinistral snails (Hoso *et al.* 2007, *Biol. Lett.*).

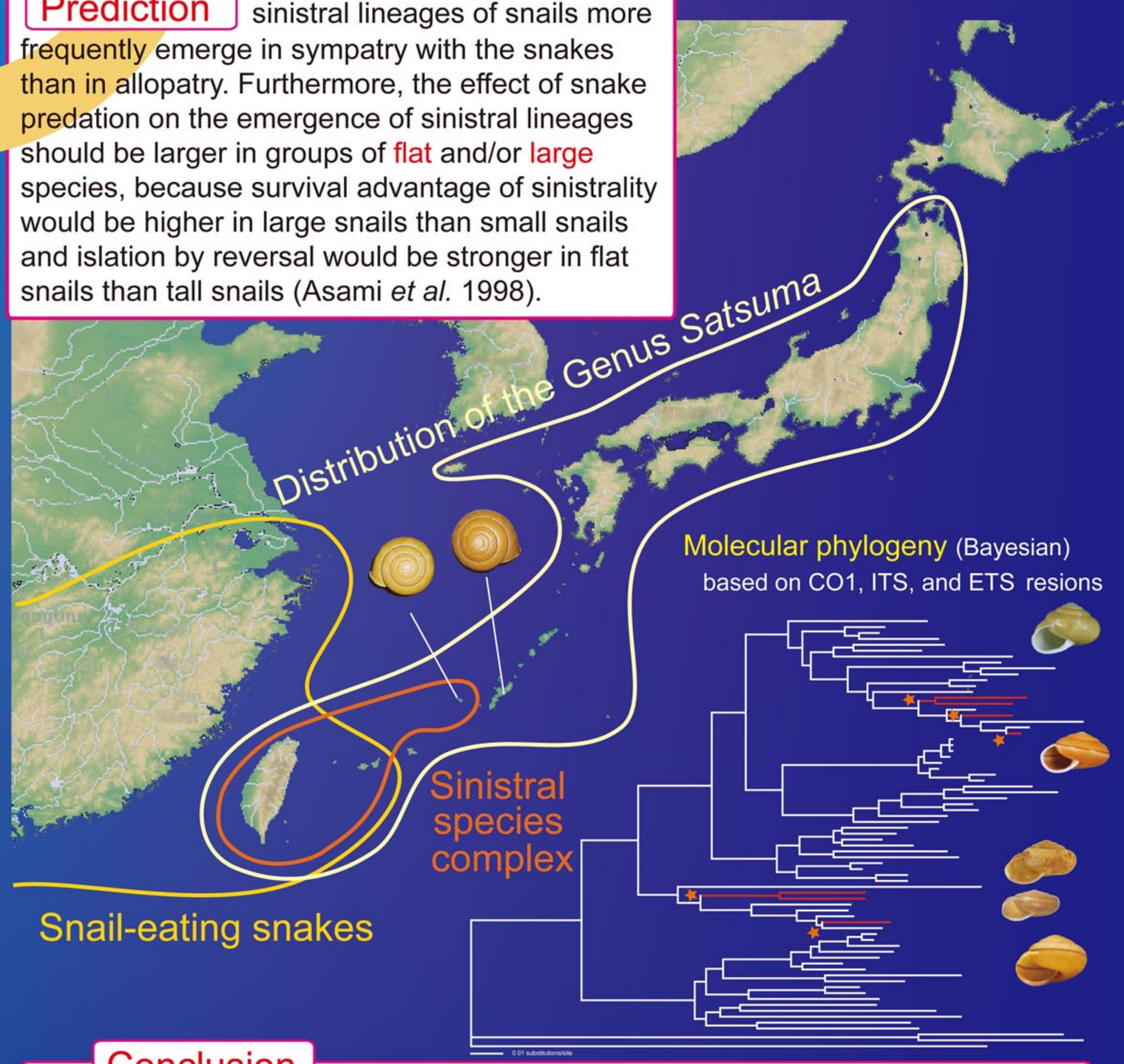
Prediction

My hypothesis predicts that sinistral lineages of snails more frequently emerge in sympatry with the snakes than in allopatry. Furthermore, the effect of snake predation on the emergence of sinistral lineages should be larger in groups of flat and/or large species, because survival advantage of sinistrality would be higher in large snails than small snails and islation by reversal would be stronger in flat snails than tall snails (Asami *et al.* 1998).

Comparative survey of biogeography



Shell-size and shell-shape dependent association of distributions between sinistral snails and snail-eating snakes. Each bar indicates the proportion of genera composed of sinistral species. I mitigate the potential bias due to diversification of sinistral genera after a single evolutionary event of reversal by analyzing data in GLMM where each family into a random factor.
Examined snails are in the order Stylommatophora, excluding unsuitable species for analysis. Sympatric genera include those that are partly or fully sympatric with pareatid snakes. In 26 genera, congeneric dextrals and sinistrals were counted as independent observations.



Conclusion

Our study demonstrated how positive selection could operate for major pleiotropic effects of a speciation gene on anti-predator survival. Speciation by natural selection may initially require genetically simpler changes of phenotype than previously expected. Our evidence for the evolutionary role of single-gene pleiotropy resurrects Goldschmidt's controversial idea of hopeful monsters.

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Hoso *et al.* 2010, *Nat. Commun.* **1**:133