

UC Santa Barbara

Posters

Title

Genital Morphology of California Land Snails From Family Xanthonychidae

Permalink

<https://escholarship.org/uc/item/5c37d4jr>

Authors

Evelyn, Christopher J, PhD

Goodward, David

Zhan, Fei

Publication Date

2023-04-01

Abstract

Sexual conflict has the potential to drive evolution of both reproductive behavior and genital morphology. This project investigates evidence for sexual conflict in genital morphology of simultaneous hermaphrodite shoulderband snails, Family Xanthonychidae. Shoulderband snails are a group of land snails which occur in coastal, foothill, mountain, and desert habitats across California. This study uses measurement data from 12 species from across Southern California. It focuses on the role of sexual behaviors in shaping the morphology of reproductive organs, including the length of the penis+epiphallus, vagina, bursa diverticulum, and bursa tract. The research findings will provide insight into the natural selection and evolutionary processes that have driven the development of reproductive organs and gross morphology in California land snails. Consistent with coevolution, male (penis + epiphallus) and female (vagina) length showed a strong and significant positive correlation in the data. A strong positive correlation was also found between spermatophore length (flagellum) and the sperm storage organ (bursa diverticulum). This second finding is consistent with sexual conflict as control over use of a donor’s sperm. In addition, this study adds to knowledge about reproductive evolution in simultaneous hermaphrodites and highlights the importance of genital morphology in understanding the evolution of sexual traits in snails. Further studies are needed to explore the functional significance of these correlations and their implications for reproductive strategies and mating behaviors in snails. This study will contribute to a better understanding of diversification in the Land Snails of Southern California.



Resources: Santa Barbara Museum of Natural History photo taken by Fei Z.

Research Goal

Explore whether morphological patterns in the genital morphology of California land snails in the Family Xanthonychidae is consistent with the pattern of sexual conflict found in other simultaneous hermaphrodite mollusks (Anthes & Michiels, 2008). Our use of specimens from natural history collections highlights the value of this material even decades after they were collected. By digitizing these specimens collected by Walter B. Miller, Dave Goodward, and others, we have created a digital record to support the physical specimens in case of damage or deterioration. We thank Santa Barbara Museum of Natural History and Los Angeles County Museum for their support.



Anza Borrego Desert C. Evelyn

Challenges

Sexual behaviors are powerful pressures that cause the diversification of many sexual traits, like the morphology of sperm-producing and female structures, and sexual promiscuity (Parker, 2016). However, in this study, California land Snails are a type of hermaphrodite that makes the sexual behaviors hard to identify and analyze the various competitive relationships in sexual traits.



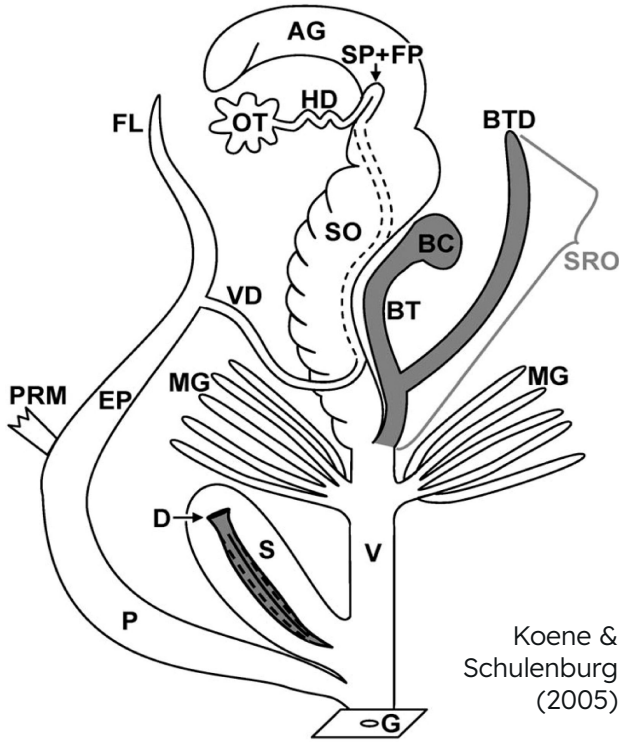
Resources: Santa Barbara Museum of Natural History (All Images)

Methods

In recent years, biologist Dave Goodward and Walter B. Miller from the Santa Barbara Museum of Natural History previously collected and dissected snails from 32 species across Southern California. For this study, I used a subset of the specimens, specifically 56 samples from 12 species, based on the quality and quantity of specimens available. Each snail was identified primarily based on their genital morphology, with the genital organs preserved in the specimen for further use in the morphometric analysis. To investigate the hypothesis of genital morphology changes in snails, I used a digital measuring software, tpsDIG, to record the measurements of the vagina, penis + epiphallus, flagellum, bursa tract, and bursa diverticulum. Then, linear analysis of those measurements in R studio were converted into meaningful and readable numbers. One scatterplot matrix of partial correlation tests were performed to examine the correlation of copulatory organs, and partial correlations between the length of five anatomical organs. The data were analyzed via R language.



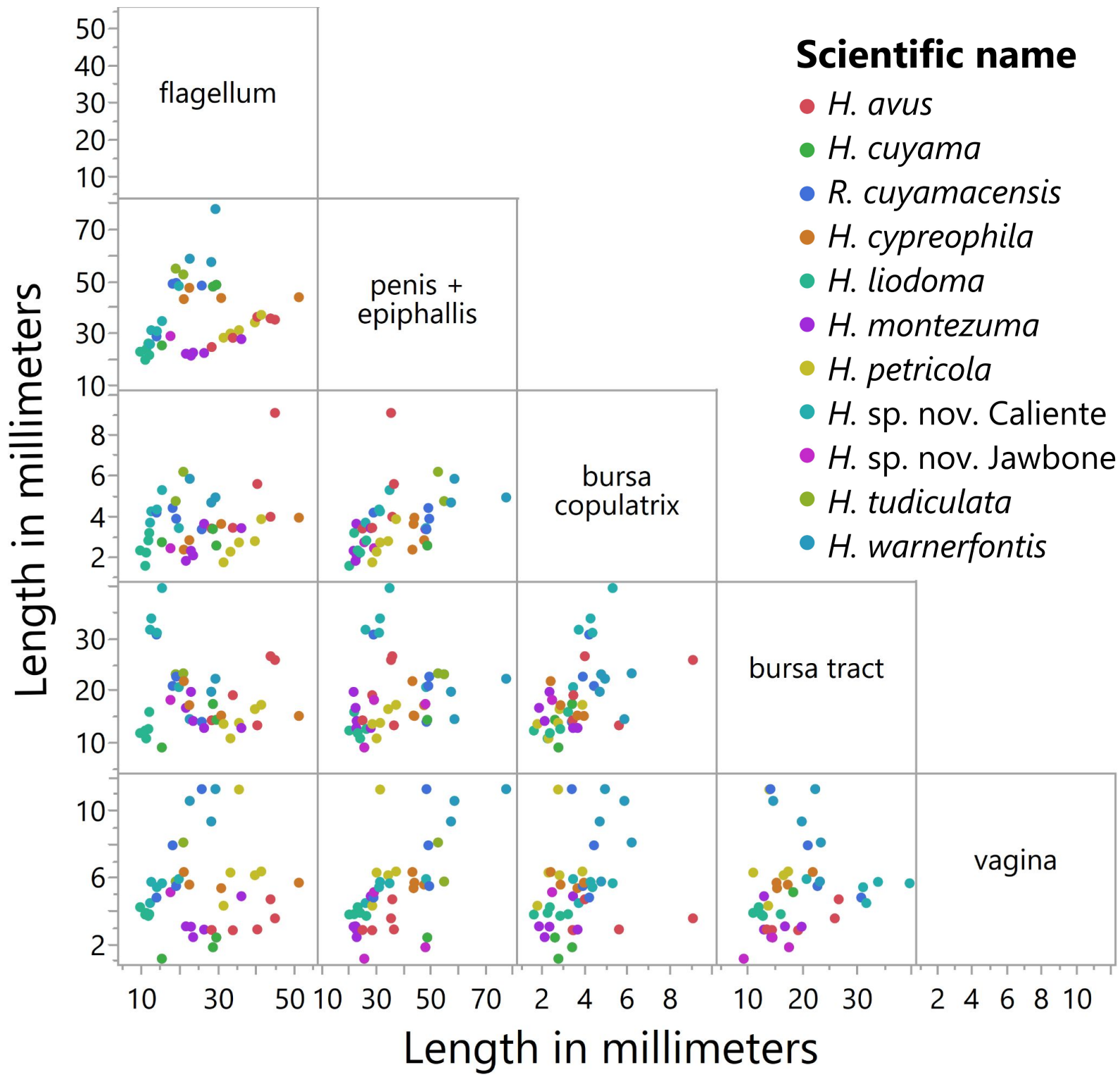
D. Goodward Personal Collections. Photo by D. Goodward.



Koene & Schulenburg (2005)

Results

There is a positive correlation between the length of penis+epiphallus and the length of vagina. The result of the Pearson Correlation test between the two variables confirmed this positive correlation, while the correlation coefficient is 0.66. Plus, the p-value < 0.001*, less than the alpha level of 0.05, which means the correlation is statistically significant.



The partial correlation between the lengths of flagellum/ penis+epiphallus is -0.14 and p-value=0.35, means this correlation is not statistically significant. The partial corr. between the lengths of flagellum/bursa tract is -0.48 and p-value<0.001*, means a moderate negative correlation that is statistically significant. The partial correlation between the lengths of flagellum/bursa diverticulum is 0.58 and p-value <0.001*, displays a significant positive correlation. The partial correlation between the lengths of flagellum/vagina is 0.13 with p-value=0.39, so the correlation is not statistically significant. The partial correlation between the lengths of penis+ epiphallus/bursa tract is -0.20 and p-value=0.17, which makes this correlation not statistically significant. The partial correlation between the lengths of penis+epiphallus/bursa diverticulum is 0.50 with p-value<0.001*, resulting in a significant positive correlation. The partial correlation between the lengths of penis+epiphallus/vagina is 0.67 and p-value<0.001*, so there is a significant positive correlation. The partial correlation between the lengths of bursa tract/bursa diverticulum is 0.59 and p-value<0.001*, which shows a positive significant correlation. The partial correlation between the lengths of the bursa tract/vagina is 0.22 and p-value=0.14, so it is not statistically significant. The partial correlation between the lengths of vagina/bursa diverticulum is -0.27, p-val=0.07, which means the correlation is not statistically significant.

Discussion

The results of this study indicate that there is a positive correlation between the lengths of copulatory organs in snails, particularly between the lengths of penis + epiphallus and vagina. This suggests that an increase in the length of the penis+epiphallis is associated with an increase in the length of the vagina. These findings are consistent with previous studies that have shown a correlation between genital morphology and mating behavior in gastropods (e.g., Kameda et al., 2010; Sun et al., 2012). For example, Kameda et al. (2010) found not only that the penis and vagina lengths were positively correlated in the land snail Euhadra peliomphala, but males with a longer penis had a higher reproductive success rate because of better access to the female organs. This selection pressure is evidence of sexual conflict, with an expected response in the female organs. Similarly, Sun et al. (2012) found that the lengths of penis and epiphallus were positively correlated with the length of vagina in the freshwater snail Bellamya aeruginosa, and that this correlation was associated with differences in reproductive success. The partial correlation analysis conducted in the present study aimed to explore the relationships between different sexual tracts. The results showed both positive and negative correlations between variables. For example, as the flagellum lengthens, the length of the bursa tract decreases, and the length of the bursa diverticulum increases. (flag produce, bd store) As the length of the penis+epiphallus increases, the length of the vagina decreases, and the length of the bursa diverticulum increases. As the bursa tract lengthens, so does the length of the bursa diverticulum. While the statistical significance of some results did not reach the alpha level of 0.05, significant correlations indicate a relationship between copulatory organ morphology and mating behaviors in snails. Overall, all results provide valuable insights into the evolution of sexual traits in this group. The findings further support the idea of copulatory organ morphology plays an important role in mating behavior in gastropods.



Santa Catalina Island C. Evelyn

Future directions

This study used a relatively small sample size and only examined a limited number of species. Future studies with larger sample sizes and more diverse species could provide a more comprehensive understanding of the relationship between snail genital morphology and reproductive success. Moreover, future studies can focus on how variable reproductive organs are within one species, to identify which organs are least variable within a species and most variable between species. This is an essential aspect of taxonomy, as species descriptions often do not state how many dissections were performed (Smith & Brown, 2015). In addition, future studies can investigate the mechanisms underlying these partial correlations within organs to explore adaptive significance of copulatory organ morphology in snails and other gastropods. Finally, this dataset could be used to investigate the taxonomy and relatedness of snails in the Family Xanthonychidae by examining the patterns of the genital morphology in phylogeny.

Care to support more student research at the Cheadle Center?

Please visit the following website to make a gift of support to the ongoing care of the natural history collections, research, and student opportunities at the Cheadle Center.



SCAN ME