Feeding and growth of native and exotic apple snails (Ampullariidae): Invasives eat more and grow more.

Wendy Morrison
NMFS Sustainable Fisheries
2010 Knauss Sea Grant Fellow

Mark Hay
Georgia Institute of Technology

My thesis was divided into four studies:

1. Induced chemical defenses in a freshwater macrophyte suppress herbivore fitness.

2. **Feeding and growth of apple snails (Ampullariidae): Invasives eat more and grow more.**

3. Latitudinal patterns in the palatability of freshwater macrophytes.

4. Herbivores prefer plants that are evolutionarily naïve: Herbivore preference for native vs exotic plants.

Background:

•Apple snails are large gastropods with a voracious appetite for freshwater macrophytes.

•Name is from their size.

•They are obligatory air breathers.

•High fecundity (over 2000 eggs per clutch)!

Background:

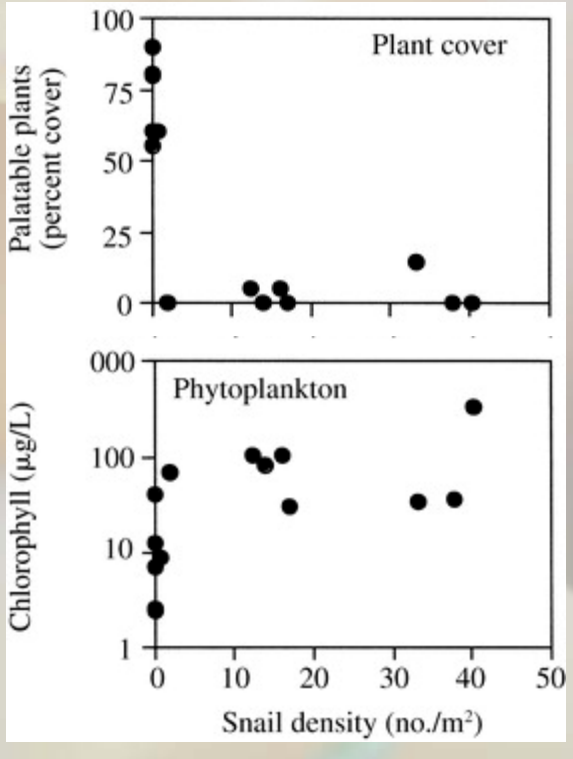
•Apple snails are native to South America (1 native to Florida is exception).

•Apple snails have been introduced in Asia and Hawaii for aquaculture.

•Their introduction into Taiwan cost US$30 million in lost rice farming revenue in 1986 alone (Mochida 1991).

•They can also have large environmental impacts: In Thailand, introduction of snail changed habitat from clear macrophyte dominated system into turbid plankton dominated system (Carlsson et al. 2004).

•Currently listed on 100 top invasive species list (Lowe et al. 2000).



The golden apple snail alters ecosystem functioning in Asian wetlands. Carlsson et al. 2004

Background:

•Within the United States, there is one native and five exotic apple snail species. All are found in S. Florida in and around the Everglades (Rawlings et al. 2007).

•One of the invasive species is currently on the outskirts of the Okefenokee Swamp in Georgia.

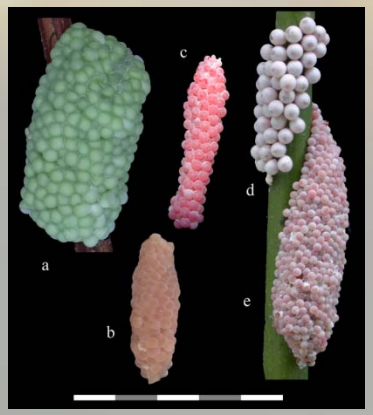
•Native apple snails are the main food source for the endangered snail kite (Bennetts et al. 1994).

Background:

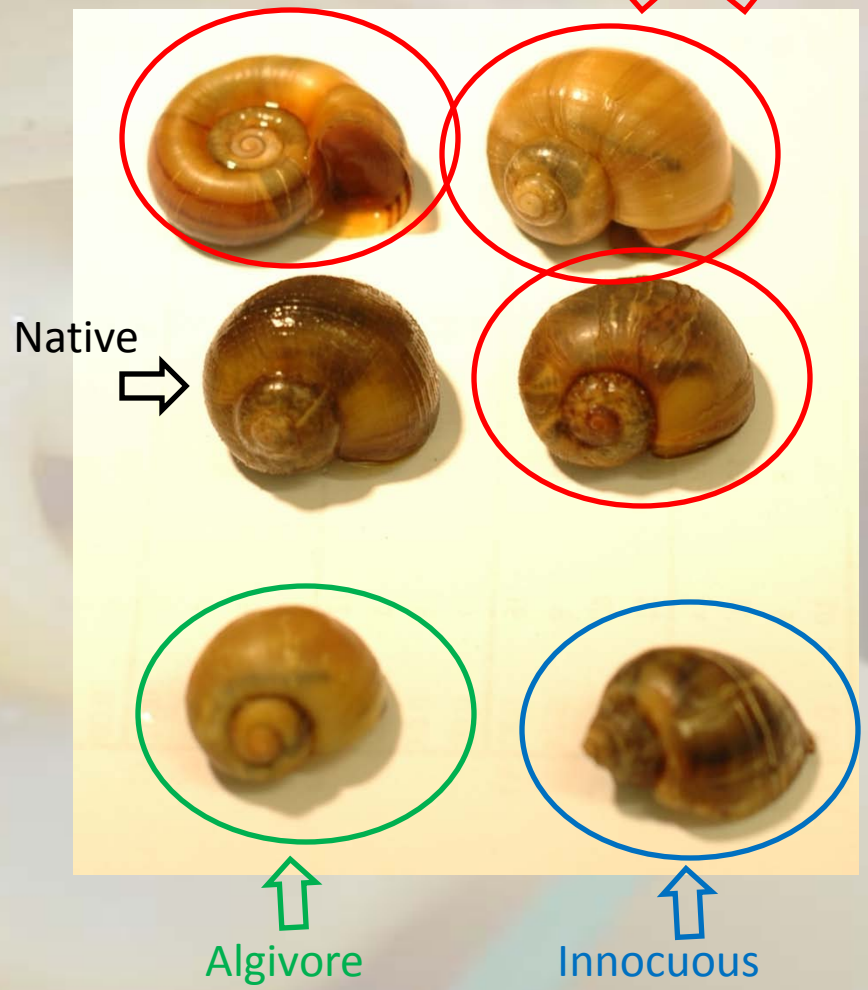
•The exotic species differ in their perceived risk and in their "invasiveness":

•3 species are considered invasive and a pest: *Pomacea insularum, P. canaliculata,* and *Marisa cornuarietis.*

•*P. Haustrum and P. diffusa* are exotic but considered innocuous.



(Rawlings et al. 2007)



Overall objective:

•To predict how replacement of the native apple snail by invasive species could impact the Everglades habitats.

Methods:

•Completed lab studies to investigate differences between native, invasive, and innocuous snail species in:

a) Food preference

b) Plant consumption

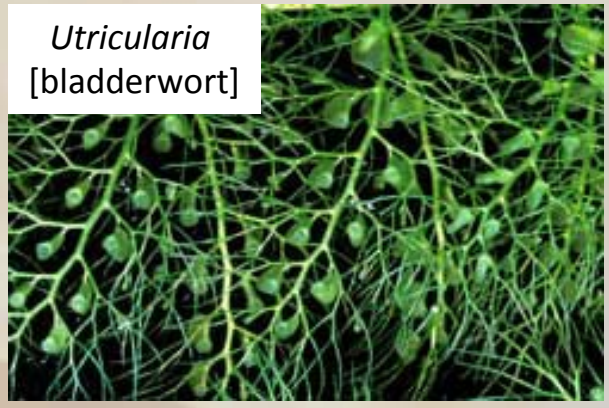
c) Growth

d) Mortality

Plants utilized:

Pontederia
[pickerel]

Nymphaea
[water lilly]



Utricularia
[bladderwort]

Sagittaria
[arrowhead]

Bacopa
[waterhyssop]

Panicum
[maidencane]

Eleocharis
[spike rush]

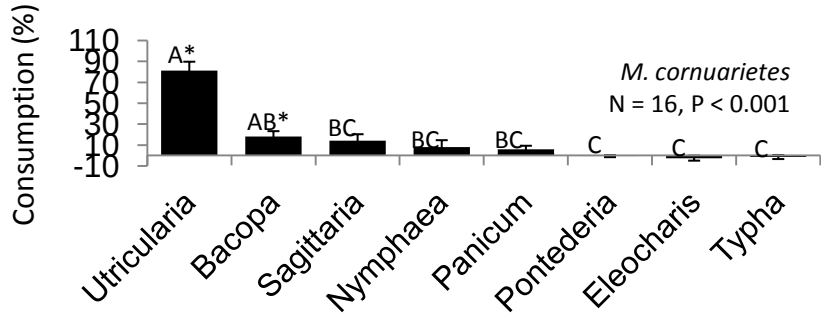
Typha
[cattail]

a-b) Plant preferences and consumption

Methods:

•Snails were offered all 8 plants simultaneously and allowed to feed for 3 days.

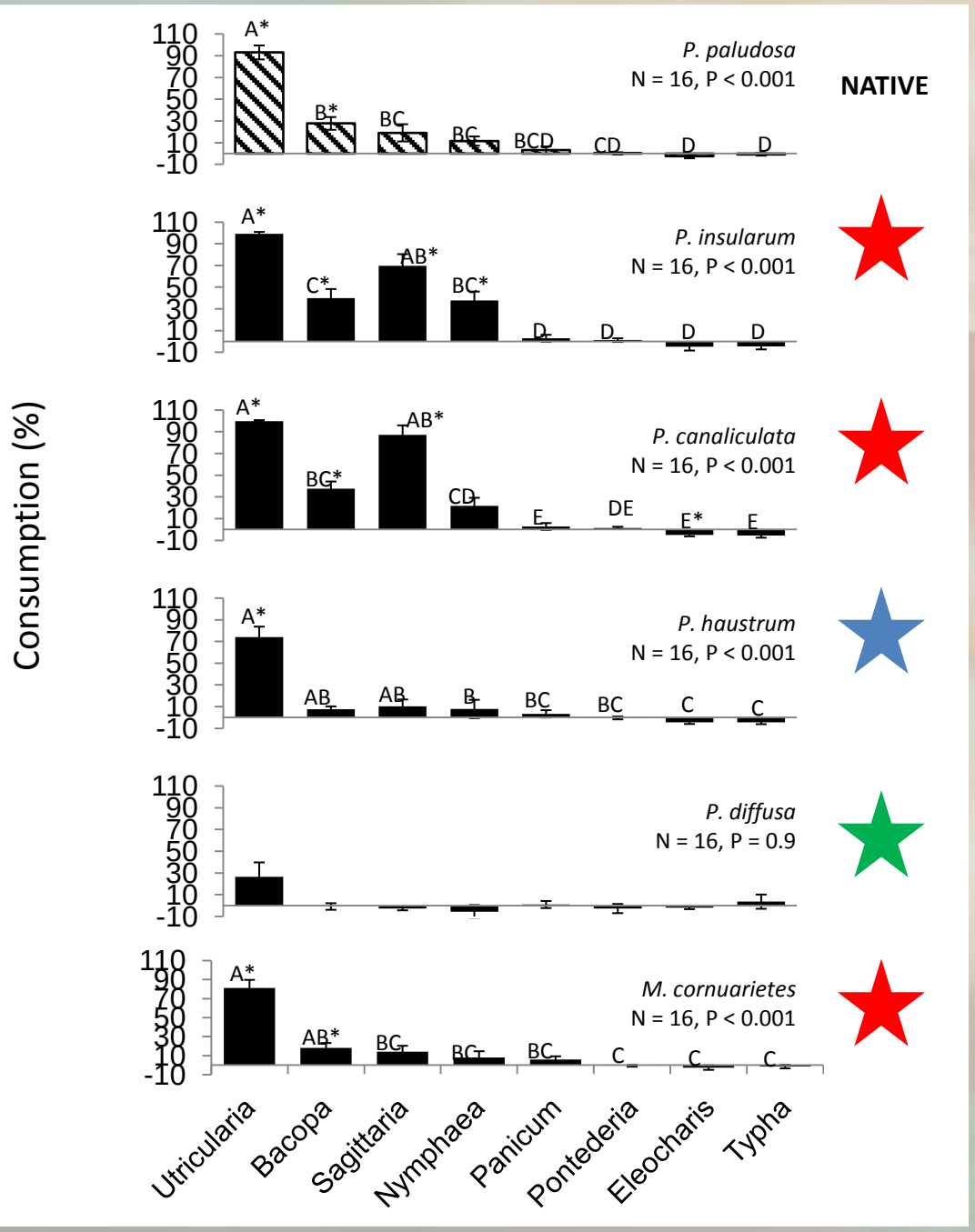
•Weights of plants consumed were measured and percent eaten calculated.



Results: plant preferences

*significantly different than zero

A-E: Different letters mean results are significantly different



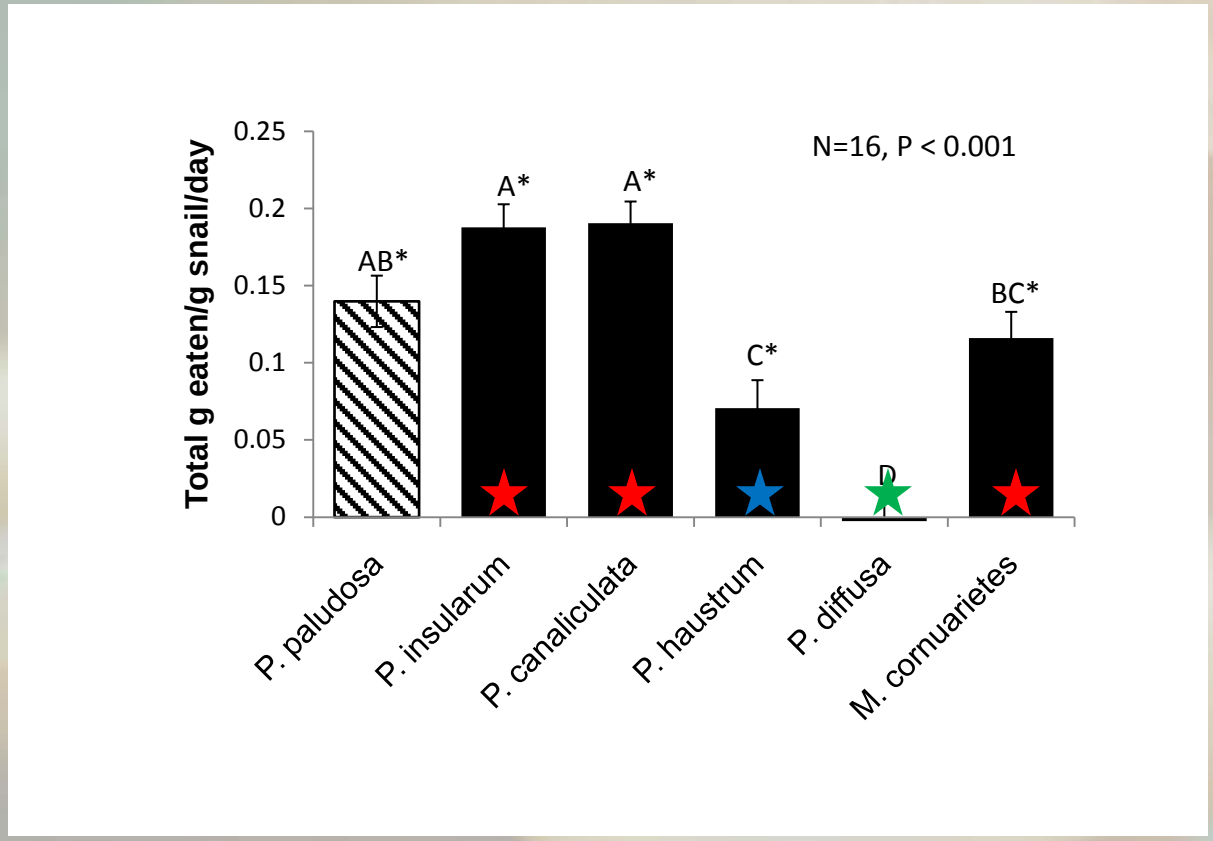
Results: plant preferences

*significantly different than zero

A-E: Different letters mean results are significantly different

NATIVE
Invasive
Algivore
Innocuous

Results: total consumption



NATIVE
Invasive
Algivore
Innocuous

c) Growth

Methods:

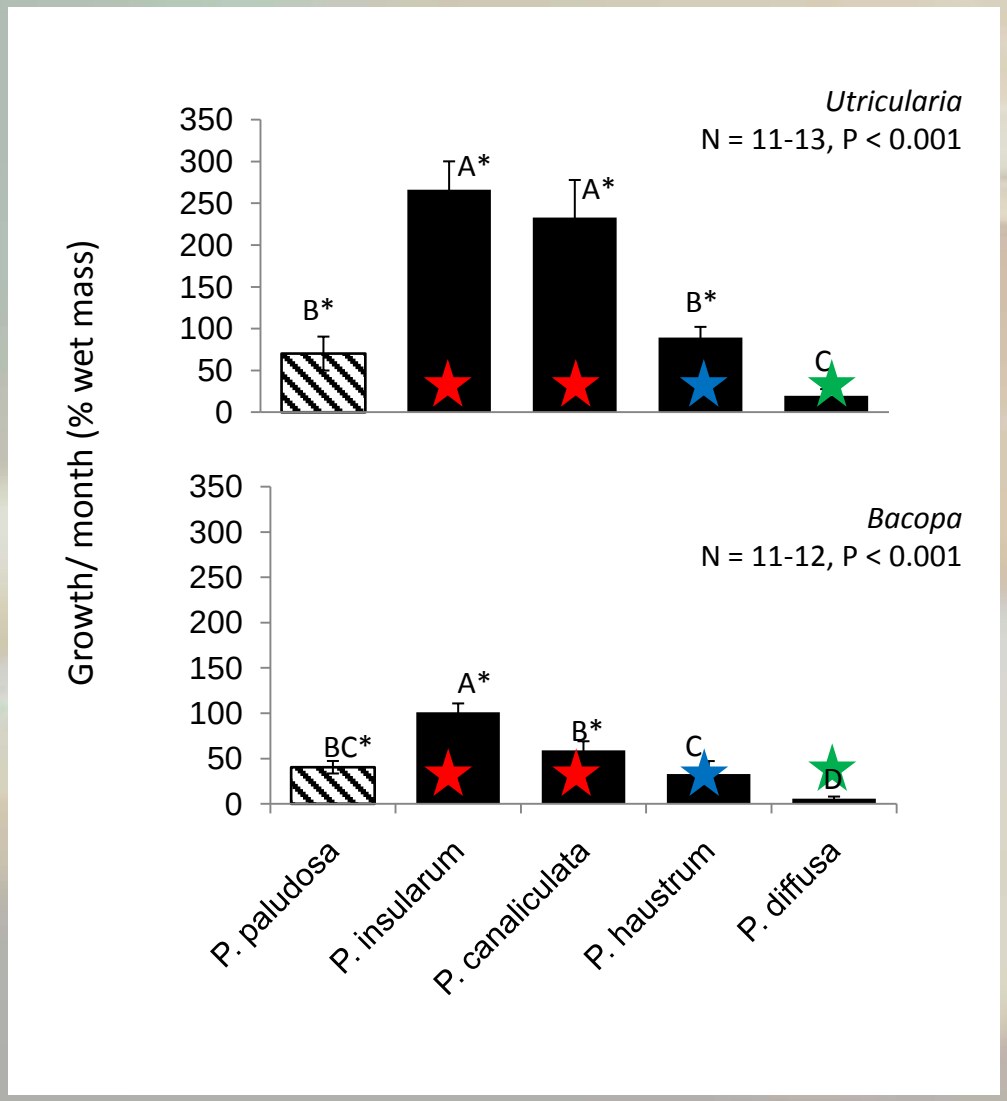
•Individual snails were randomly assigned to a plant treatment and provided as much of that plant as they could eat for one month.

•Growth of the snails was measured as a change in mass and change in length.

•6 plants were included in this experiment plus a control to measure growth in snails offered no food (N= 7 treatments).

•This was a huge undertaking:
5 snail species x 7 plant treatments x 16 replicates = 528 individual snail cups!!

Results: growth



NATIVE
Invasive
Algivore
Innocuous

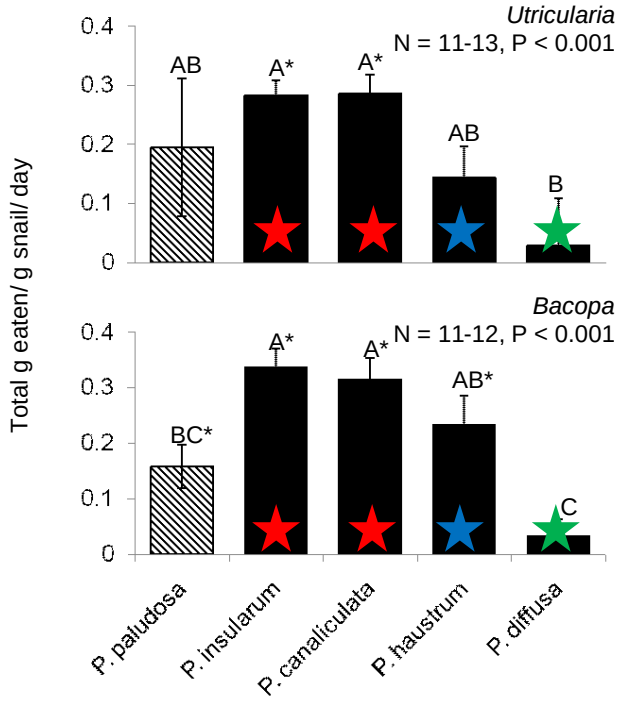
Results snail growth:

•Control snails (i.e. starved snails) did not grow and had the highest mortality (22%)

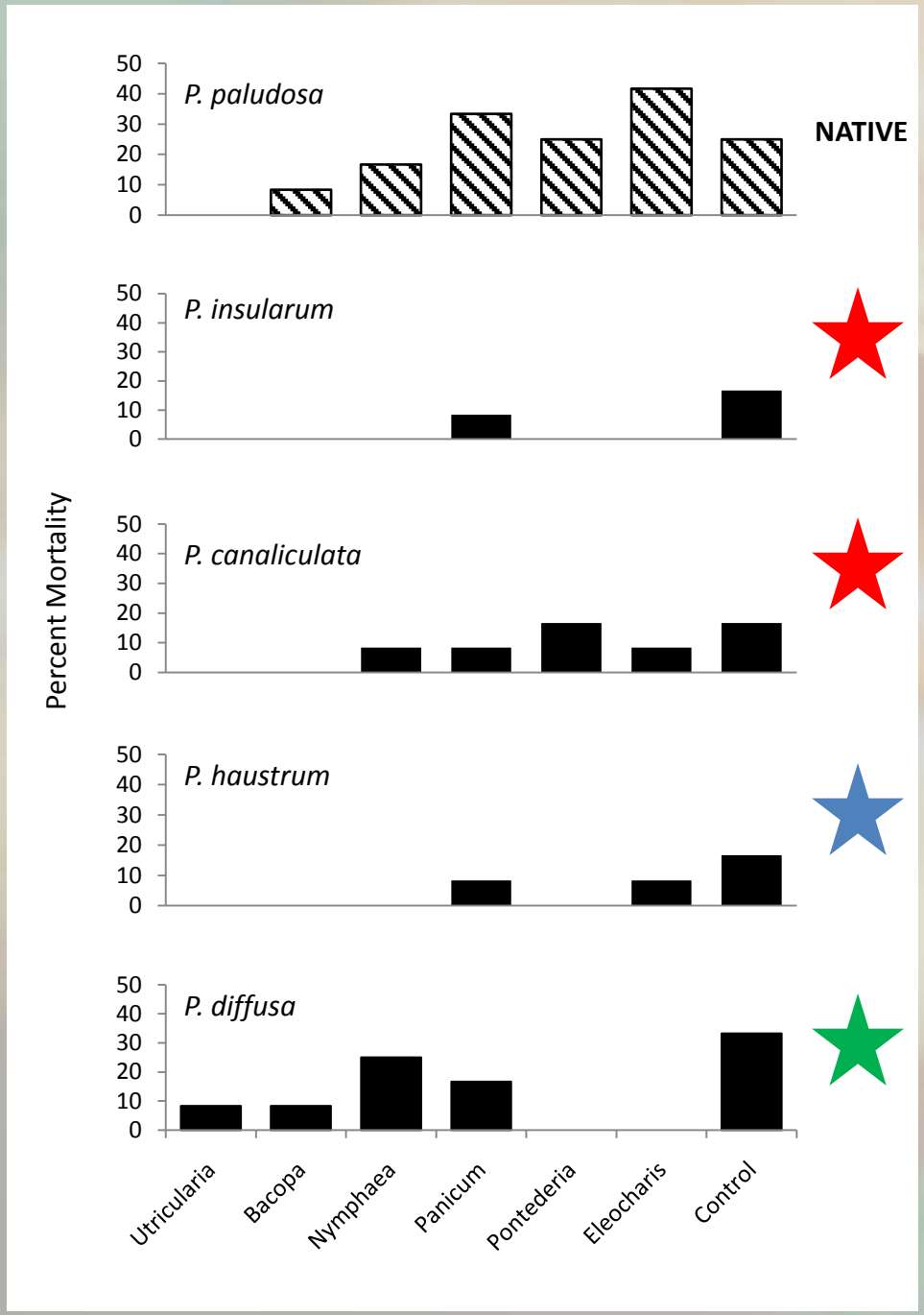
•None of the snail species grew on the three low preference plants: *Panicum, Pontederia, or Eleocharis.*

•Only *P. insularum* showed significant growth on N*ymphaea*.

Results: consumption



NATIVE
Invasive
Algivore
Innocuous


Percent Mortality
50
40
30
20
10
0
P. paludosa
NATIVE
P. insularum
P. canaliculata
P. haustrum
P. diffusa
Utricularia
Bacopa
Nymphaea
Panicum
Pontederia
Eleocharis
Control
NATIVE
Invasive
Algivore
Innocuous

Conclusions:

The Good News:

Preference was similar across all species (except the algivore *P. diffusa*)

Four of the eight plant species were not consumed even when there was no other choice (maidencane, spikerush, pickerel, and cattail).

This suggests that the transformation documented in Thailand (apple snails transformed the clear macrophyte dominated system into a turbid plankton dominated system) will not occur in S. Florida.

The Bad news:

The invasive species *Pomacea insularum* and *P. canaliculata* tended to eat more, grow more, and have lower mortality than the native species *P. paludosa.*

Our study suggests that one of the first plants to be impacted would be bladderwort (*Utricularia*).

Okefenokee Swamp in Georgia has not evolved with any apple snail species. Introduction of the invasive species there could have large ramifications.

Conclusions:

Other factors not considered in our study may be important:

Fecundity is much higher in the invasive species: native snail has ~30 eggs per batch while *P. insularum* can have 1000's! (Barnes et al. 2008)

Abundance (snails per square meter) was similar between the native and invasive species in STABLE ecosystems. However, in agricultural ecosystems, the invasives can increase in abundance by 130x [130 vs 1 snails per square meter]! (Burlakova et al. 2009)

P. Insularum grows to 4x larger than the native *P. paludosa*.

Recent research on the endangered snail kite suggests that the extra effort necessary to eat the larger invasive snails could have a negative impact on the survival of this endangered species.

References:

Barnes, M. A., R. K. Fordham, and R. L. Burks. 2008. Fecundity of the exotic applesnail, *Pomacea Insularum*. J. N. Am. Benthol. Soc 27(3):738-745.

Bennetts, R. E., Collopy, M. W., and J. A. Rogers, Jr. 1994. The snail kite in the Florida Everglades: A food specialist in a changing environment. In: Davis, S.M, and J. C. Ogden (eds) Everglades, The Ecosystem and Its Restoration. St. Lucie Press, Delray Beach, Florida, pp 507- 532

Burlakova, L. E., A. Y. Karatayev, D. K. Padilla, L. D. Cartwright and D. N. Hollas. 2009. Wetland restoration and invasive species: apple snail (*Pomacea insularum*) feeding on native and invasive aquatic plants. Restoration Ecology 17: 433-440.

Carlsson, N.O., C. Bronmark, and L. Hansson. 2004. Invading herbivory: The golden apple snail alters ecosystem functioning in Asian Wetlands. Ecology 85: 1575-1580

Carlsson, N.O. 2006. Invasive golden apple snails are threatening natural ecosystems in Southeast Asia. In: R. C. Joshi and L. S. Sebastian (eds) Global Advances in Ecology and Management of Golden Apple Snails. Phillipine Rice Research Institute, pp 61-72

Conner, S.L., C. M. Pomeroy, and P. C. Darby. 2008. Density effects of native and exotic snails on growth in juvenile apple snails *Pomacea paludosa*: A laboratory experiment. J Mollus Stud 74: 355-362

Cowie, R.H. 2002.– Apple snails (Ampullariidae) as agricultural pests: their biology, impacts, and management. In:– G.M. Baker (ed) Molluscs as Crop Pests.– CABI Publishing, NY, NY, pp 145-192

Howells, R. G. 2002. Comparative feeding of two species of apple snails (*Pomacea*). Ellipsaria 4: 14-16

Lowe S., M. Browne, S. Boudjelas, and M. De Poorter. 2000. 100 of the World's Worst Invasive Alien Species. A Selection from the Global Invasive Species Database. The Invasive Species Specialist Group. World Conservation Union. Hollands Printing Ltd. New Zealand.

Mochida, O. 1991. Spread of freshwater *Pomacea* snails from Argentina to Asia. Micronesica Suppl. 3: 51-62

Rawlings, T. A., K. A. Hayes, R. H. Cowie, and T.M. Collins. 2007. The identity, distribution, and impacts of non-native apple snail s in the continental United States. Evol Biol 7:97

Acknowledgements

My Advisor: Dr. Mark Hay
My Committee:
Dr Weissburg
Dr. Jiang
Dr. Streelman
Dr. Lorenz

IGERT Funding
TA Funding
Teasley Funding

Lots of helpers: Dad, Uncle Harold, Anya, Zach, Keri, Emily, Kirill, Melanie