



Figure 1: *Halocaridina rubra* scraping epiphyton from rocks. Animal total length approximately 7 mm.

Abstract

Both species of the Atyid shrimp genus *Halocaridina* are endemic to the Hawaiian Islands. *Halocaridina rubra* is found on several islands and usually feeds benthically. *H. palahemo* has only been found in one pool on the island of Hawaii and usually feeds pelagically. The two species are similar but have several different physical characteristics that may be related to their feeding modes. Because of this it has been suggested that they are actually the same species which develops different morphology under different feeding conditions. In this experiment, *H. rubra* was exposed to two different kinds of food sources (benthic and pelagic algae), and the physical changes of the carapace, rostrum, chelae, dactyl, setae and carpus of the first and second pereopods were tracked. The hypothesis was that the shrimp which consistently fed on pelagic algae would develop characteristics similar to *H. palahemo* including: increased inflation of carapace, shortened rostrum, decreased inflation of the chelae and lengthening of the carpus, dactyl and setae on the first and second pereopods. Although variability was observed in these shrimp over the six months of this experiment, the variability was mostly not in the pattern that would be expected if the pelagic group was transitioning to the morphology seen in *H. palahemo*. Multiple significant trends, however, were seen in that direction and it is possible that with a longer, multigenerational experiment a greater change in morphology would take place. Further experiments will be required to provide a definitive answer to the hypothesis.

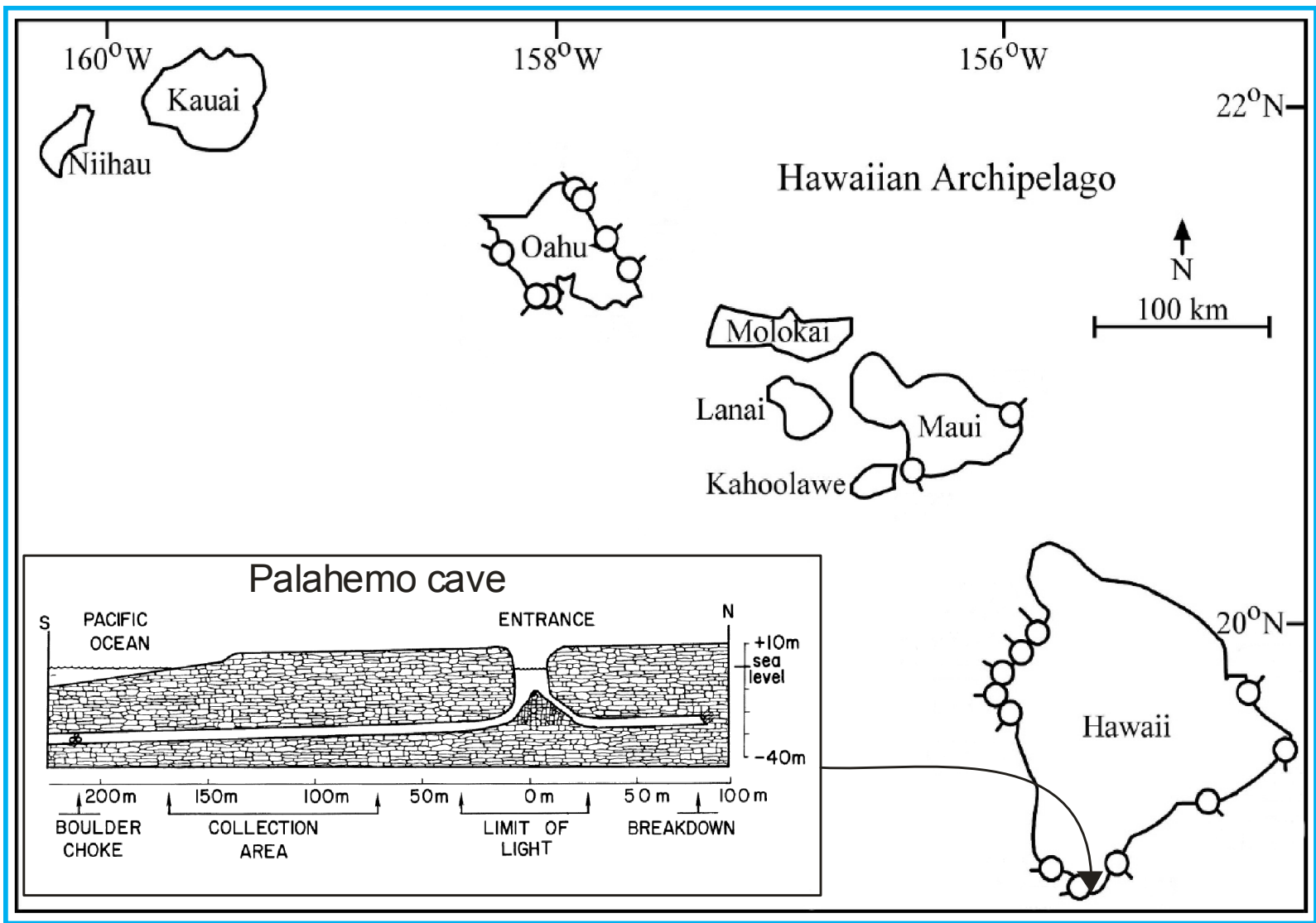


Figure 2: Locations on the Hawaiian Islands where *Halocaridina rubra* and *H. palahemo* are found. Adapted from Craft et al., (2008) and Kensley and Williams (1986).

Introduction

Although morphology of most species is so predictable that it is used for species identification, the shape of others may change with time and circumstances, such as the well-known cyclomorphosis of *Daphnia*. Cyclomorphosis-like changes, however, are unknown in most other crustaceans such as shrimp. Atyidae (Decapoda: Caridea) is a shrimp family whose members have a variety of morphologies. Some species are ‘scrapers’ with thick chelae and feed on periphyton scraped from rocks. Others are ‘filter feeders’ with long, thin, setose chelae which strain pelagic algae from the water. Of the two species in the Atyid genus *Halocaridina*, *H. rubra* (Holthuis, 1963) (Figure 1) is found in anchialine pools on several Hawaiian islands (Craft et al., 2008) (Figure 2) and has the morphology of a scraper (Figure 3A). *H. palahemo* (Kensley and Williams, 1986) has only been found in a single deeper water cave on the island of Hawaii (Figure 2) and has the morphology of a filter feeder (Figure 3B). Some have suggested that these two species are actually simply different morphotypes of the same species, with alternate morphologies induced by the feeding modes most effective in their different habitats. In this experiment, we subjected *H. rubra* to benthic and pelagic feeding conditions to see whether the morphological characteristics of *H. palahemo* could be induced over time if the shrimp fed pelagically.

Are the Hawaiian Opae-ula Shrimps *Halocaridina rubra* and *H. palahemo* Simply Different Morphotypes of the Same Species?

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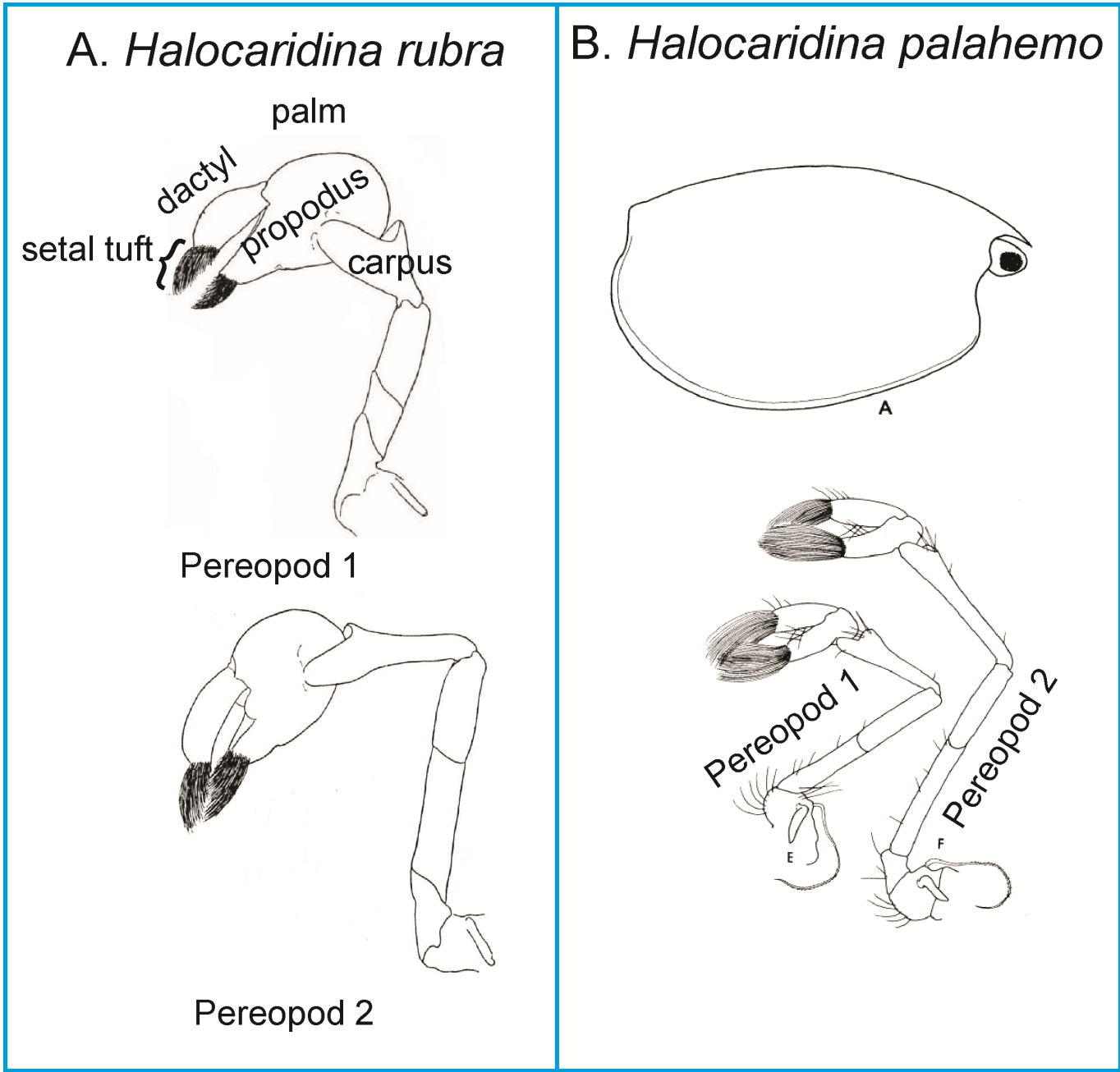


Figure 3: Drawings from the original descriptions of *Halocaridina rubra* (A, Holthuis, 1963) and *H. palahemo* (B, Kensley-Williams, 1986)

Materials and Methods

Approximately 300 *H. rubra* shrimp (“opae-ula” in Hawaiian) (Figure 1) were evenly split between two experimental tanks, one of which was configured for benthic feeding and one for pelagic. Benthic algae (primarily epiphyton on rock) were provided to the shrimp in the benthic tank, while the shrimp in the pelagic tank were fed pelagic algae (powdered *Spirulina*). The water of both tanks was gently circulated and oxygenated. The experiment continued for six months, which is enough time for multiple molts and usually enough time for several *Halocaridina* generations. At monthly intervals subsamples of shrimp were removed from each tank and 15 components of their morphology carefully measured (Figure 4). Morphological trends were assessed by regression and ANCOVA. Special attention was paid to morphological changes in shrimp in the pelagic tank that tended toward the morphology seen in *H. palahemo* (Table 1).

Results

- The shrimp did not reproduce during this experiment, so all measurements were made on the initial generation.
- During the six months of this experiment, 7 of the 15 characteristics showed a trend toward the *H. palahemo* morphology in the pelagic group but not in the benthic group (Table 1, Figure 5).
- Three characters exhibited no significant trend in either group (Table 1, Figure 6).
- Four characters trended in the *H. palahemo* direction in both groups (Table 1, Figure 6).
- None of the characters trended toward the *H. palahemo* morphology in the benthic group while not having the same trend in the pelagic group.
- One character in the pelagic group trended significantly away from the *H. palahemo* morphology in the pelagic group while not changing in the benthic group (Table 1, Figure 7).

Figure 7: The aspect ratio of the carapace is the only character which trended significantly away from *H. palahemo* morphology in the pelagic group, while remaining unchanged in the benthic group.

Table 1: Changes expected in the pelagic shrimp, based on reported differences between <i>H. rubra</i> and <i>H. palahemo</i> and on the differences between a pelagic and benthic feeding mode.	
Change Expected:	Significant Trend Observed:
Changes in Carapace and Rostrum:	
Carapace will become more inflated	Opposite trend seen
The length of the rostrum will decrease	No
The rostrum will cease to project past the eyestalks	No-mixed
Changes in Pereiopod 1:	
The palm of the first propodus will become long and thin	Yes, but also in benthic
The length of the carpus relative to the propodus will increase	Yes, but also in benthic
The length of the dactyl will increase relative to the palm	Yes
The aspect ratio of the setal tuft on the dactyl will increase	Yes
The length of the setae relative to dactyl length will increase	No
The length of the setae relative to palm length will increase	Yes
Changes in Pereiopod 2:	
The palm of the second propodus will become long and thin	No
The length of the carpus relative to the propodus will increase	Yes, but also in benthic
The length of the dactyl will increase relative to the palm	Yes
The aspect ratio of the setal tuft on the dactyl will increase	Yes
The length of the setae relative to dactyl length will increase	Yes
The length of the setae relative to palm length will increase	Yes

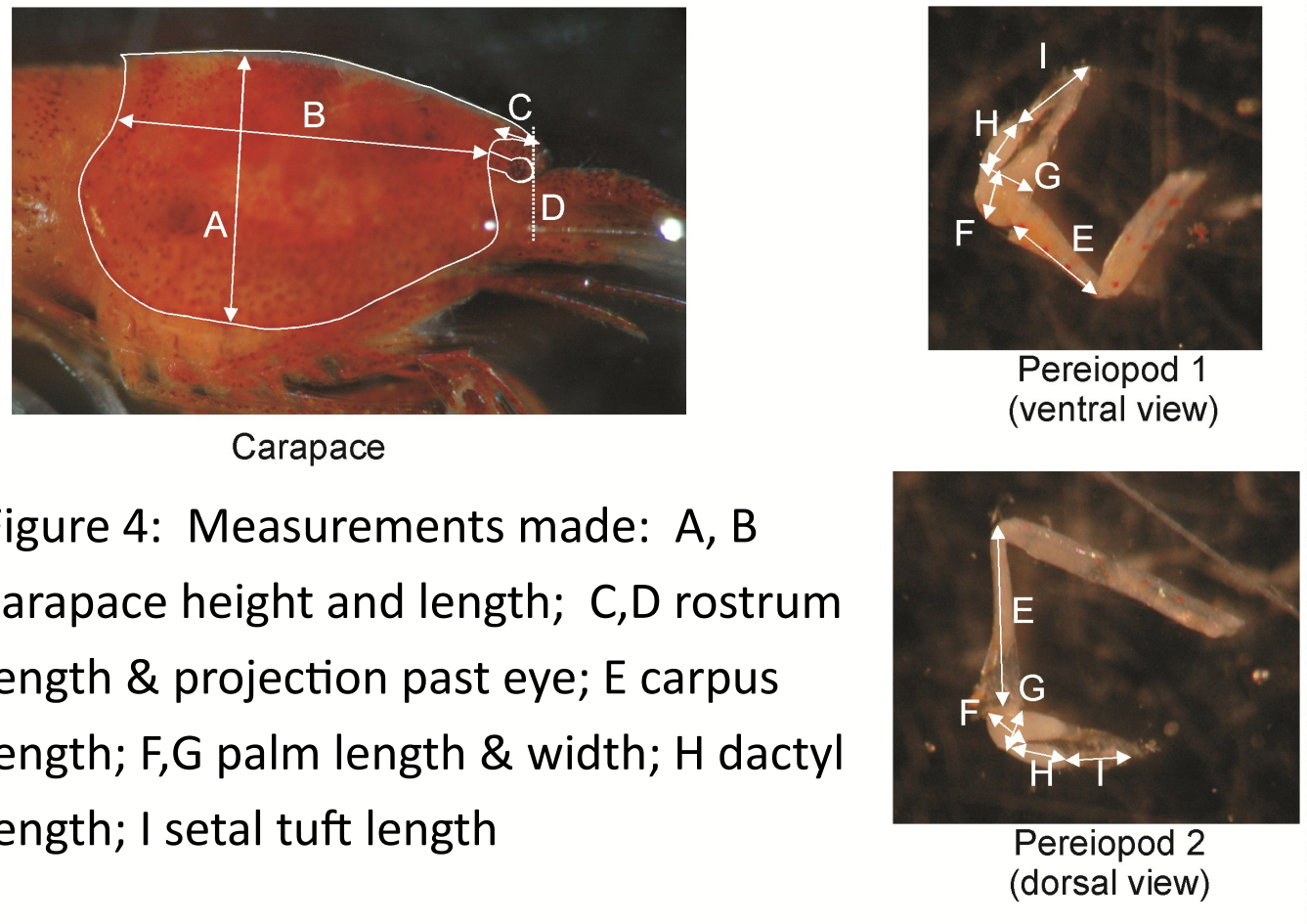


Figure 4: Measurements made: A, B carapace height and length; C,D rostrum length & projection past eye; E carpus length; F,G palm length & width; H dactyl length; I setal tuft length

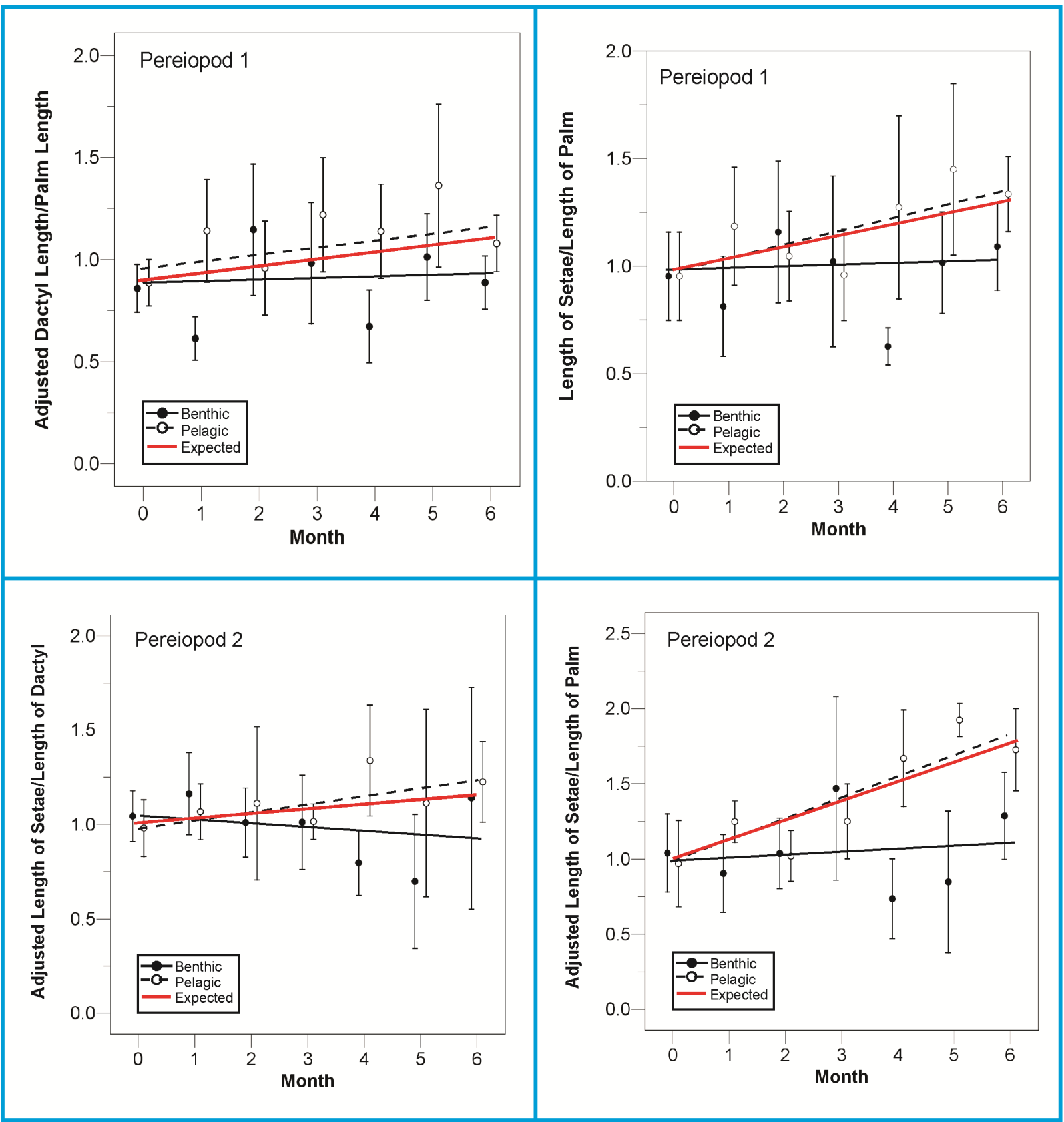


Figure 5: Examples of characters in which the pelagic group displayed a significant trend toward the morphology of *H. palahemo* but the benthic group did not.

Summary

- When placed under pelagic conditions, many morphological characters of *H. rubra* trended in the direction of *H. palahemo* morphology.
- A few characters changed in both benthic and pelagic groups, but none of the characters became more like *H. palahemo* in the benthic group without also following the same trend in the pelagic group.
- Although preliminary, these results support the suggestion that *H. palahemo* may simply be a pelagic form of *H. rubra*.
- Further tests and a multiple-generation study will be needed to fully confirm or deny the hypothesis.

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