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Morphological characteristics and species separation of Hawaiian postlarval amphidromous fishes

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Abstract—There are five Hawaiian amphidromous fishes (Gobiidae: *Lentipes concolor, Awaous guamensis, Sicyopterus stimpsoni, Stenogobius hawaiiensis;* Eleotridae: *Eleotris sandwicensis).* Amphidromous adults deposit eggs on the stream bottom. After hatching, larvae drift to the ocean for growth followed by postlarval migration back into the streams. Postlarvae were collected to construct a dichotomous identification key based on 12 morphological measures and ray counts from four fins. Overall, the presense of fused pelvic fins, standard length (SL), and fin ray numbers were the most useful in species separation. Gobies were separated from the eleotrid by the former having fused pelvic fins. Within the gobies, *S. stimpsoni* had the largest SL [mean (SD) = 20.5 (1.0) mm] with *A. guamensis* [15.8 (0.6)mm] smaller and *L. concolor* [13.7 (1.3) mm] and *S. hawaiiensis* [13.3 (1.0) mm] the smallest. Although SL alone could not separate *L. concolor* and *S. hawaiiensis*, the former had 5 first dorsal fin rays compared to 6 in all other gobies. Nineteen pectoral fin rays separated *S. stimpsoni* from *A. guamensis*, and SL along with anal and second dorsal fin ray number, separated *A. guamensis* from *S. hawaiiensis.* Canonical discriminate function analysis was used as an exploratory approach to confirm the dichotomous key. With all morphological features entered into the analysis, three significant discriminate functions were generated with the most highly correlated morphological variables within each function the same as those used in the dichotomous key. Additionally, regression models were generated for predicting SL from total length (TL) of three postlarval species. Measures of TL do not require excessive handling or killing specimens; however, SL is usually the preferred measure for body size. The ability to identify migrating postlarvae under a variety of conditions aids in data acquisition under circumstances where preservation may or may not be necessary for the research objectives.

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Introduction

The Hawaiian Islands are faced with large scale stream degradation where most streams are either partially or fully diverted, dammed, or channelized (Hawai‘i Cooperative Park Service Unit 1990). The native, amphidromous faunal populations are particularly sensitive to this stream degradation (Timbol & Maciolek 1978). Amphidromy, a form of diadromy (see McDowall 1996), involves a lifecycle with breeding adults in the stream reaches. Eggs are laid on benthic substrate, and upon hatching, larvae are swept to the ocean where growth and development occur from several weeks to months (Radtke et al. 1988), until recruitment into the streams as postlarvae. Stream degradation can: 1) destroy adult breeding habitat (e.g., channelization), 2) prevent complete larval drift to the ocean (e.g., diversions), and 3) obstruct postlarval recruitment back into breeding stream habitat (e.g., weirs and dams).

Five amphidromous fish species are native to Hawai‘i with four endemic (Gobiidae: *Lentipes concolor, Sicyopterus stimpsoni, Stenogobius hawaiiensis;* Eleotridae: *Eleotris sandwicensis)* and one indigenous (Gobiidae: *Awaous guamensis)* to the Indo-Pacific. For better stream management, an understanding of all life history features of these fishes is necessary. An important part of achieving this understanding is the accurate identification of goby larvae and postlarvae in order to recognize species differences in breeding periodicity and postlarval recruitment. Kinzie (1990) summarized the taxonomy and morphology of the adult fishes while Tate et al. (1992) provided a field key to the larvae and postlarvae that primarily relies on pigmentation for species differentiation, and Lindstrom (1998) presented an additional larval key that was confirmed using mtDNA. However, a postlarval key that can be used for specimens having lost pigmentation when preserved for laboratory analyses is lacking. An identification key of this type should be based primarily on morphological measurements to be used as a corroboration of pigmentation differentiation. In addition, morphological characteristics can be useful for developing allometric models of growth and development in future studies.

The objectives of this project were to quantify morphometric differences between the species of postlarval stream fishes in Hawai‘i, develop a short dichotomous key complimented with photos and explore and confirm dichotomous separation using *a posteriori* discriminate function analysis. A dichotomous key based on these data is presented in this paper, in addition to qualitative descriptions (e.g, pigmentation patterns and head/body shape) useful in separating live specimens without the aide of magnification. Additionally, we wanted to provide useful models for predicting standard length from total length of three postlarval species (i.e., *L. concolor, A. guamensis,* and *S. stimpsoni)*, where total length does not require excessive handling or killing specimens. The ability to identify migrating postlarvae under a variety of conditions aids in data acquisition under circumstances where preservation may or may not be necessary for the research objectives.

Although measurements are given for all five species, this paper emphasizes the differences between *L. concolor, A. guamensis,* and *S. stimpsoni,* which is represented by sample size differences between these three species and *E. sandwicensis* and *S. hawaiiensis.* The primary three gobies *(L. concolor, A. guamensis,* and *S. stimpsoni)* have completely fused pelvic fins, forming a ventral sucker, and for this reason, are capable of most commonly climbing waterfalls as postlarvae, and more infrequently as small juveniles (Benbow et al. 2002). *Stenogobius hawaiiensis* does have a ventral sucker; however, this species and *E. sandwicensis* (no ventral sucker) do not climb waterfalls, and they are both restricted to downstream reaches near the stream mouth that are typically influenced by saltwater. Thus, emphasis has been placed on the three species that are most commonly found migrating together in Hawaiian streams and are the most difficult to differentiate.

Methods

The postlarvae of *L. concolor, A. guamensis* and *S. stimpsoni* used for morphological separation were collected on two dates during July 1994 using a modified Breder trap (Breder 1960, Burky et al. 1994). All trapping in 1994 occurred in the lower reaches of ‘I-ao Stream, Maui, Hawai‘i. Traps were set ~ 200 m upstream of the mouth in the channelized portion of ‘I-ao Stream. The design and function of these traps ensured that all specimens were actively migrating (unpublished data), therefore, there is little chance that specimens may have ceased migration to continue further growth to sizes larger than those determined to be

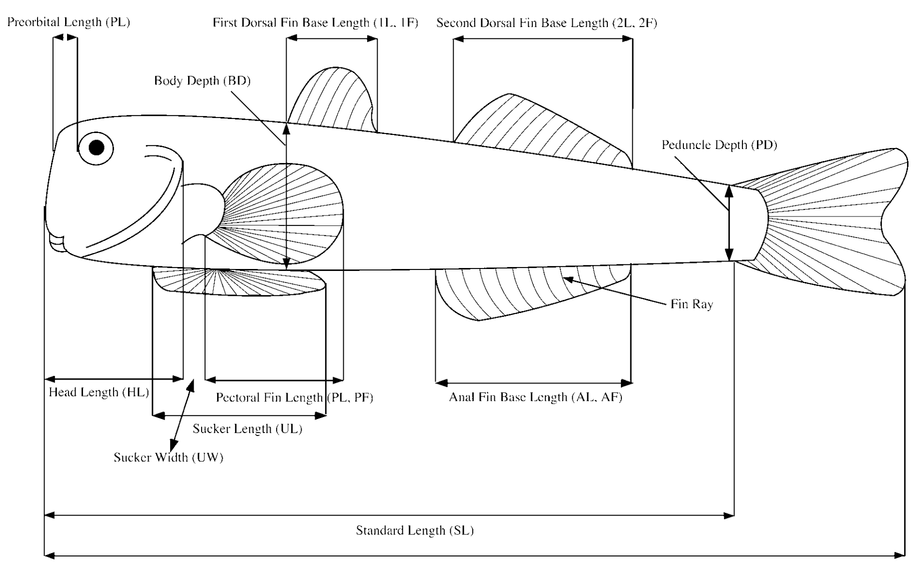

Figure 1. A stylized postlarva with the measurements, counts and representation of terms (and abbreviations) used in the morphometric analysis of Hawaiian amphidromous fish postlarvae.

Table 1. Measurements and ray counts for the postlarvae of Hawaiian amphidromous fishes. The single asterisk indicates ray count modes (and ranges) taken from a larger number of specimens (individually preserved) than indicated in parentheses at the top of each column (see text for details). All bolded and italic characteristics were used in the dichotomous key. All underlined characters are those features used in the species descriptions. The abbreviations in parentheses for each morphological characteristic are those used in the text for each character.

Morphological Characteristic	*Lentipes concolor* (n = 20)		*Awaous guamensis* (n = 20)		*Sicyopterus stimpsoni* (n = 18)		*Stenogobius hawaiiensis* (n =5)		*Eleotris sandwicensis* (n =1)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Total Length (TL)	16.6	1.4	19.5	0.6	<u>25.7</u>	0.9	16.4	1.0	<u>17.2</u>
Standard Length (SL)	13.7	1.3	***15.8***	0.6	<u>20.5</u>	1.0	***13.3***	1.0	<u>13.6</u>
Preorbital Length (PL)	0.7	0.3	1.1	0.1	1.5	0.4	0.7	0.1	1.0
Body Depth (BD)	1.6	0.3	2.4	0.3	2.5	0.4	1.8	0.1	2.3
Peduncle Depth (PD)	1.0	0.1	1.2	0.2	1.7	0.3	1.0	0.2	1.5
Head Length (HL)	2.9	0.4	4.1	0.4	4.6	0.4	3.7	0.1	3.9
Sucker Width (UW)	<u>1.7</u>	0.3	2.3	0.5	2.2	0.3	2.0	0.3	***sucker absent***
Sucker Length (UL)	<u>1.8</u>	0.2	2.7	0.3	2.5	0.3	2.3	0.2	***sucker absent***
Pectoral Fin Base Length (PL)	2.6	0.3	3.6	0.3	3.9	0.3	2.8	0.2	3.3
Pectoral Fin Ray No. (PF)	16 (14-17)		16 (13-17)		***19 (18-19)***		15		17
Anal Fin Base Length (AL)	3.1	0.3	3.7	0.2	<u>4.9</u>	0.4	3.6	0.2	1.8
*Anal Fin Ray No. (AF)	11 (9-12)		11 (10-12)		12 (11-12)		12 (12-13)		9
First Dorsal Fin Base Length (1L)	1.0	0.2	1.9	0.2	2.1	0.3	1.3	0.3	1.4
****First Dorsal Fin Ray No. (1F)***	***5***		6 (6-7)		6		6		6
Second Dorsal Fin Base Length (2L)	3.1	0.3	3.8	0.2	<u>5.2</u>	0.4	3.7	0.2	2.0
*Second Dorsal Fin Ray No. (2F)	11 (11-12)		11 (10-12)		12 (11-12)		12		10

*The total replicates used for these fin ray counts are given for the following species: N = 37 *(L. concolor)*, N = 34 *(A. guamensis)*, N = 30 *(S. stimpsoni)*. Individually preserved specimens were used for additional ray counts.

migrating postlarvae (e.g., juvenile life stage). Thus, for the purposes of this paper we define individuals captured during active migration as postlarvae. Collected postlarvae were immediately preserved in 3 - 4% formalin in the field. The one specimen of *E. sandwicensis* was collected from Wai-ehu Stream, Maui and the five *S. hawaiiensis* specimens were collected from Ka-ʻaʻawa Stream, Oahu (specimens collected by M. Yamamoto and G. Higashi and provided to S. Hau).

In the laboratory, morphological measurements and fin ray counts were made as shown in Figure 1. From 64 postlarvae, 12 body features were measured to the nearest 0.1 mm under an Olympus dissecting microscope with fiber optic lighting, and using a stage micrometer. Ray counts were made from four fins on the 64 original postlarvae, and on several additional individually preserved specimens of *L. concolor* (N = 17 additional), *A. guamensis* (N = 14 additional), and *S. stimpsoni* (N = 12 additional). These additional specimens were used to increase the sampling sizes of certain fin ray counts (due to damaged fins of the original 12 specimens), thus accounting for the total sample size differences for these features (Table 1). Body measurements/counts included total length (TL), standard body length (SL), head length (HL), preorbital length (PL), body depth (BD), peduncle depth (PD), sucker length and width (UL and UW, respectively), first dorsal fin length (1L), second dorsal fin length (2L), anal fin length (AL), and pectoral fin length (PL) (Figure 1). Ray counts were made from the first and second

Table 2. Summary descriptions of other anatomical characteristics (e.g., pigmentation) used to distinguish Hawaiian amphidromous postlarvae. These descriptions were based on observations made on the measured postlarvae and are relative to postlarval interspecific differences. Some terminology of the descriptions comes from Tate et al. (1992), where additional, more specific information on pigmentation and shape is presented.

Anatomical Characteristics	*Lentipes concolor*	*Awaous guamensis*	*Sicyopterus stimpsoni*	*Stenogobius hawaiiensis*	*Eleotris sandwicensis*
Body Size/ Pigmentation	Small/ opaque to translucent with little pigmentation	Intermediate/ moderately pigmented, dark verticle bars	Large/darkly pigmented	Small/almost translucent, very little pigmentation	Variable/ Darkly pigmented except in small specimens
Head/Snout	Torpedo shaped with a subterminal mouth	Rounded, not semicircular, subterminal mouth	Subterminal or inferior mouth, snout semicircular in shape, three notches in upper lip	Rounded, not semicircular, subterminal mouth	Head dorsoventrally flattened, superior mouth
Caudal Fin	Slightly forked	Truncate, with a black mark at base	Forked or truncate	Truncate	Rounded or truncate with a small black spot at base
Other Fins	Base lengths usually shorter than other species	A black spot and two stripes on first dorsal fin	Two or 3 stripes on second dorsal fin and one stripe on first dorsal fin and one on the anal fin	Single stripe on first dorsal fin	Two stripes on first dorsal fin and 3 on second dorsal fin

dorsal fins (1F and 2F, respectively), anal fin (AF), and pectoral fin (PF) (Figure 1). Effort was made to make measurements and counts without damage to the specimens; however, some specimens were dissected in order to achieve accurate anatomical measurements. Modes were determined for ray counts. It should be noted that although the modes represent the most frequent counts, there were ranges for some species and specific fins, which can be accounted for by improper preservation and handling which resulted in ripping or smashing; thus, making it difficult to separate and count rays. When this was the case, fin ray count ranges

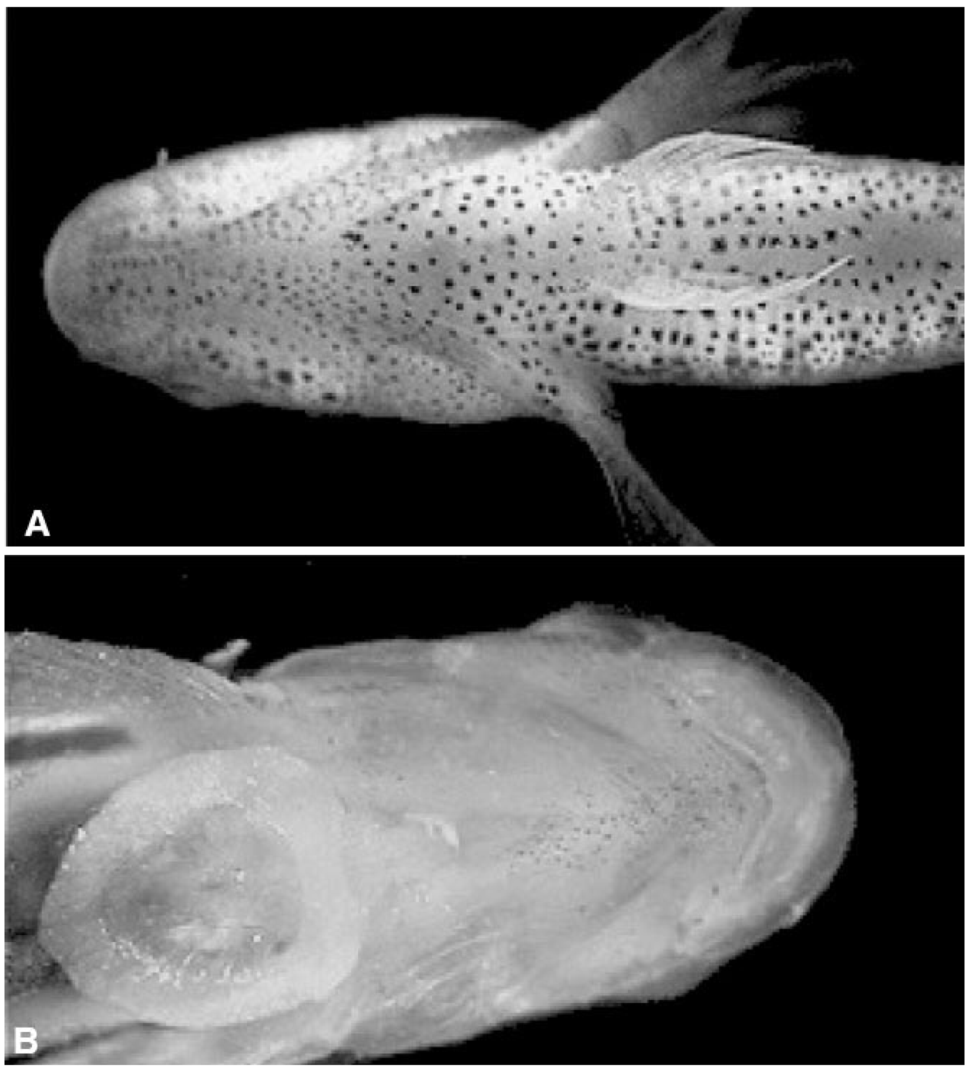

Figure 2. Open pelvic fins of *Eleotris sandwicensis* (A) and fused on *Sicyopterus stimpsoni* (B) forming a ventral sucker. The other gobies all have similar suckers.

were presented in the text of the results section (see below). With proper preservation (individual storage in buffered formalin) ray counts were more easily made without dissection.

Notes on qualitative features (e.g., pigmentation, head/snout shapes) were also made for each species during measurements and counts (Table 2). Some terminology used in the qualitative species descriptions follows that of Tate et al. (1992). For more thorough descriptions of pigmentation and other body features see Tate et al. (1992).

In order to generate models for predicting standard length from total length, linear regressions were calculated for each species using the statistical package JMP (JMP 2001). For exploratory *a posteriori* confirmation of dichotomous morphological separation we preformed a canonical discriminant function analysis using the statistical package SPSS (SPSS 1995) on *L. concolor* (N = 20), *A. guamensis* (N = 20), *S. stimpsoni* (N = 18) and *S. hawaiiensis* (N = 5) using all morphological characteristics included in Table 1. Although it is relatively difficult to meet the assumptions of this multivariate technique, it can provide exploratory power in order to develop testable hypotheses (Williams 1983), and has been used to successfully discriminate between species of other organisms (Williams 1983, Umphrey 1996). Our data did not satisfy all of the assumptions of this technique, so the results have only been used to make comparisons to the morphological features used in the dichotomous key, and are not intended to test any hypothesis.

Results and Discussion

Postlarval Dichotomous Identification Key

Based on the morphological measurements and fin ray counts in Table 1, in addition to some notes on pigmentation (Table 2), we developed the following dichotomous key:

1. Pelvic fins not fused, ventral sucker absent (Fig. 2A). . . . . ***Eleotris sandwicensis*** (Eleotridae)
1. Pelvic fins fused, forming a sucker on the ventral midline (Fig. 2B). . . . . (Gobiidae)
    2. First dorsal fin ray number always of 5 (Fig. 3A). . ***Lentipes concolor***
    2. First dorsal fin ray number of 6 (Fig. 3B). 3
3. Pectoral fin ray number almost always of 19 (Fig. 4A). . . . . ***Sicyopterus stimpsoni***
3. Pectoral fin ray number from 14 - 17, but usually 15 or 16 (Fig. 4B) . . 4
    4. Standard length from 15 - 17 mm; anal fin and second dorsal fin ray number from 10 - 12 (mode 12); body opaque or pigmented, not translucent; usually a cluster of melanophores at base of first dorsal fin and a vertical bar of melanophores at the base of caudal fin (Fig. 5A) . . . . ***Awaous guamensis***

4. Standard length usually less than 15 mm; anal fin ray number from 12 -13 (mode 12) and second dorsal fin with 12 rays; body translucent and not robust; no vertical melanophore bar at base of caudal fin (Fig. 5B) . . . . ***Stenogobius hawaiiensis***

Morphological Data and Additional Characteristics

Mean values of body morophological measurements and ray count ranges and modes are given in Table 1, while corresponding qualitative descriptions of the body, head, and fins are found in Table 2. The absence of a ventral sucker, fin ray number (i.e., 1F, PF and AF) and standard length (SL) were the most important anatomical features separating all five species (Table 1). However, sometimes it was difficult to achieve accurate ray counts due to damaged specimens. Therefore, we have provided the ray count ranges (and modes) along with body length measurements (e.g., SL, TL, HL) and some pigmentation descriptions.

The postlarvae of *E. sandwicensis* were easily separated from the others by the absence (pelvic fins not fused) of a ventral sucker. Tate et al. (1992) reported SL ranges of *E. sandwicensis* larvae and postlarvae as 12.0 – 14.0 and > 16.0 mm, respectively. In a study of postlarval recruitment from Hawai‘i Island, Nishimoto and Kuamo‘o (1997) reported trap-captured *E. sandwicensis* with a mean SL = 13.5 ± 0.4 (SD) mm from 783 specimens. Therefore, the one specimen that we report here is probably somewhat larger than those that are typically captured with traps. Only those species with fused pelvic fins forming a sucker (the Gobiidae) are compared hereafter.

Postlarvae of *L. concolor* and *S. hawaiiensis* were the smallest (mean SL = 13.7 and 13.3, respectively) and similar in most body measurements (e.g., TL, SL, 2L, BD, PD) except for HL *(S. hawaiiensis* had a longer head relative to SL) and body pigmentation (Tables 1 and 2). A unique distinguishing character for *L. concolor* was five fin rays of 1F, while all other species had six (one specimen of *A. guamensis* had 7). *Stenogobius hawaiiensis* was unique with 15 PF rays, but PF rays were difficult to count in some *L. concolor* and *A. guamensis* (e.g., specimens which were not preserved individually). Thus, PF may lead to erroneous counts and subsequent misidentification if used alone. The small sample size of *S. hawaiiensis* may also have given somewhat conservative SL measurements. From 13 specimens, Tate et al. (1992) report a SL range of 15.0 – 19.0 mm, and Nishimoto and Kuamo‘o (1997) reported a mean SL of 14.1 ± 0.5 (SD) mm from 62 trap-captured specimens. Thus, the specimens presented in this paper are probably representative of smaller *S. hawaiiensis* recruits. It has also been reported that the postlarvae will shrink by up to 0.5 mm in SL after immediately entering the stream from the ocean (Nishimoto & Kuamo‘o 1997).

Sicyopterus stimpsoni was the largest (mean SL = 20.5 ± 1.0 mm) species with a mode of 19 PF rays, which taken together, separates this species from the others (Figure 2). Although the mode is 19 PF rays, only one out of 30 specimens was found to have 18 rays. In addition, the dark pigmentation and semicircular snout of S. stimpsoni (Figure 6) allows for quick identification without magnifi-

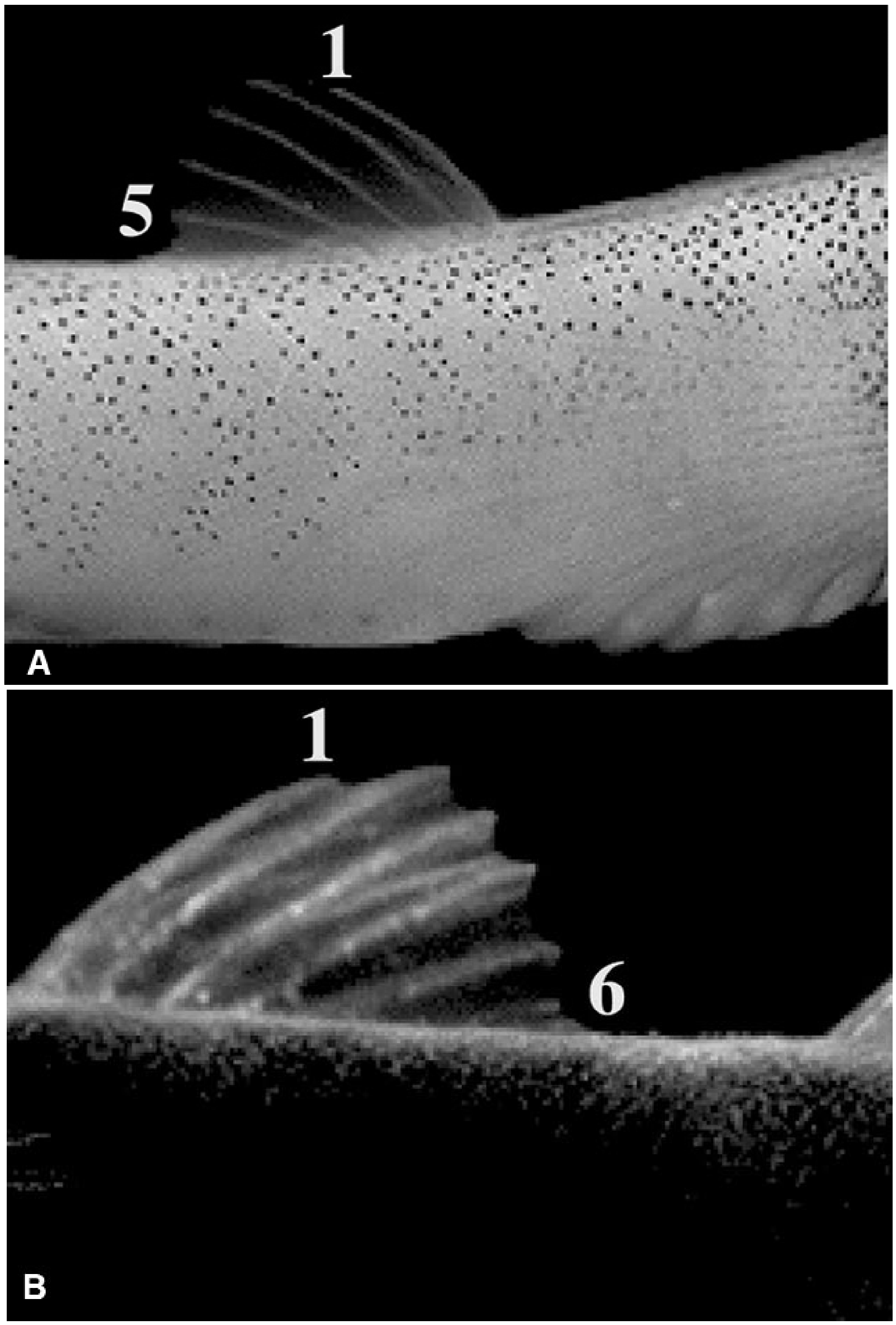

Figure 3. The first dorsal fin of *Lentipes concolor* (A) and *Sicyopterus stimpsoni* (B). The first dorsal fin ray number for *L. concolor* is always of five; the other gobies have six.

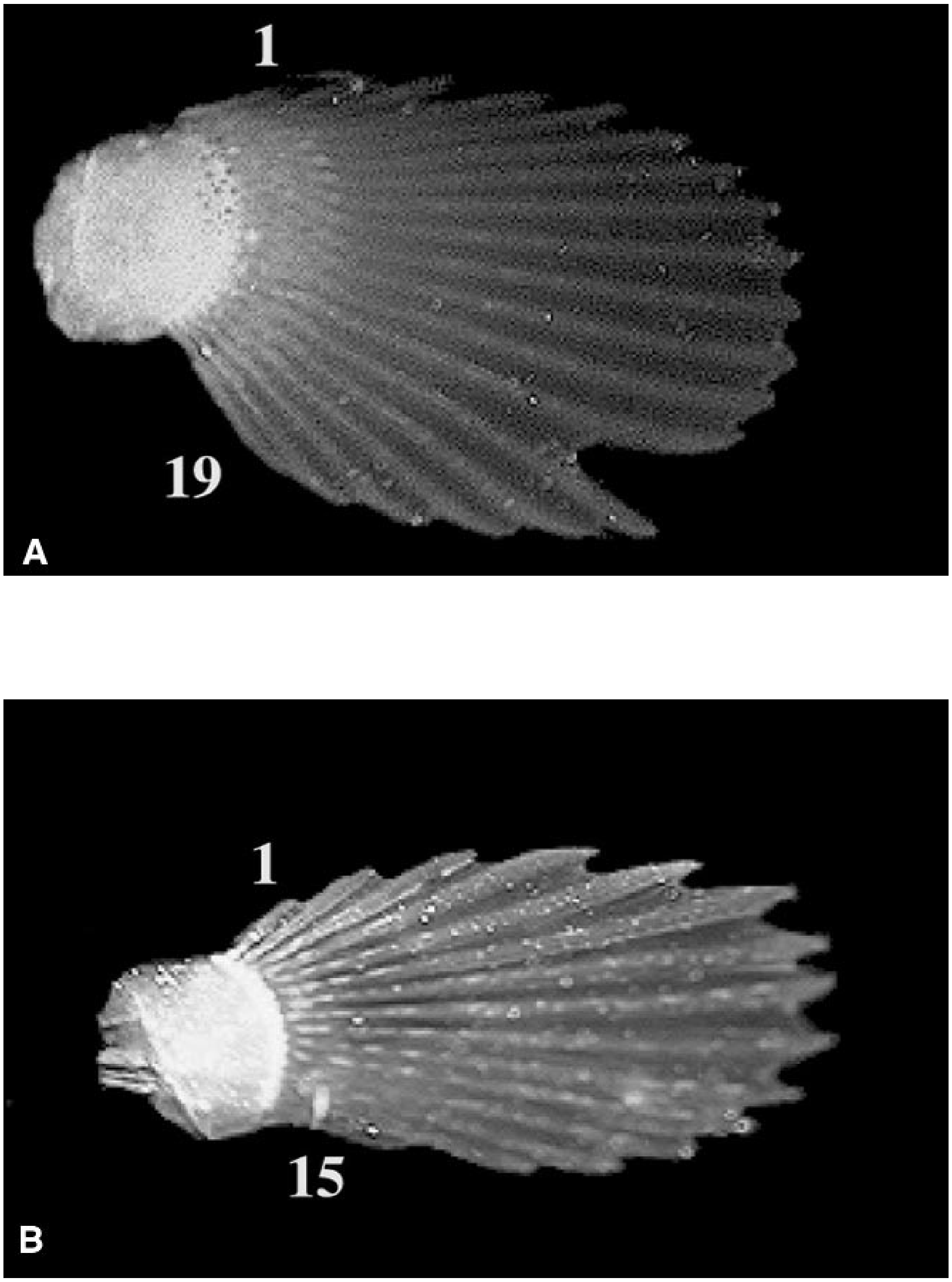

Figure 4. The pectoral fin of *Sicyopterus stimpsoni* (A) and *Stenogobius hawaiiensis* (B). The pectoral fin ray number for *S. stimpsoni* is 18 or 19, depending on the condition of the specimen; the other gobies have from 14 to 17 with modes of 15 or 16 (Table 1), depending on species and condition.

cation, which is important for live identification in the field. Tate et al. (1992) reported a SL range of 20.0 – 24.0 mm for *S. stimpsoni* and Nishimoto and Kuamoʻo (1997) reported a mean (SD) of 23.6 (0.6) mm. Thus, our specimens represent a smaller mean SL than previously reported. This may be due to the organisms being captured ~ 200 m upstream of the mouth, when they have already gone through metamorphosis. Tate et al. (1992) discuss body length reduction in *S. stimpsoni* due to ventral rotation of the subterminal mouth after entering the stream.

Figure 5. The side view of *Awaous guamensis* (A) and *Stenogobius hawaiiensis* (B). The standard body length of *S. hawaiiensis* is usually < 15.0 mm, whereas, *A. guamensis* ranges from 15.0 – 17.0 mm. The scale bar for each photograph equals 1 mm. In the key, anal and second dorsal fin ray number separate these two species; however, these photos do not show the fins stretched out for counting. Thus, several rays of each fin are squeezed together next to the body. In addition, note the pigmentation differences between these species. *Awaous guamensis* is typically characterized by a vertical, dark bar near the base of the caudal fin and another dark spot near the posterior base of the first dorsal fin. *Stenogobius hawaiiensis* is nearly translucent with little or no pigmentation.

Awaous guamensis has an intermediate SL (mean = 15.8 ± 0.6 mm), is never translucent as in *L. concolor* and *S. hawaiiensis,* and usually has darkly pigmented vertical bars running longitudinally along the midline of the body and a dark caudal bar (Table 2; Figure 5). This mean SL for *A. guamensis* is within the range reported by Tate et al. (1992) and Nishimoto and Kuamo'o (1997); however, Tate et al. (1992) also report that postlarval *A. guamensis* can be captured with SL from 16.0 – 22.0 mm, when the caudal bar is most noticeable.

Within the Hawaiian postlarval gobies, overall body size, as SL or TL, showed *S. stimpsoni* > *A. guamensis* > *L. concolor* = *S. hawaiiensis* (Table 1 and Figure 6). The SL values reported for *S. stimpsoni, A. guamensis, L. concolor* and *S. hawaiiensis* generally agree with ranges of Tate et al. (1992) and Nishimoto and Kuamo'o (1997). The additional morphological features (i.e., 2F, 2L, UW, UL, PL, AL, AF, 1L) given in Table 1 can aid in the identification of poorly preserved or disfigured specimens when the more distinguishing characteristics are damaged or indiscernible.

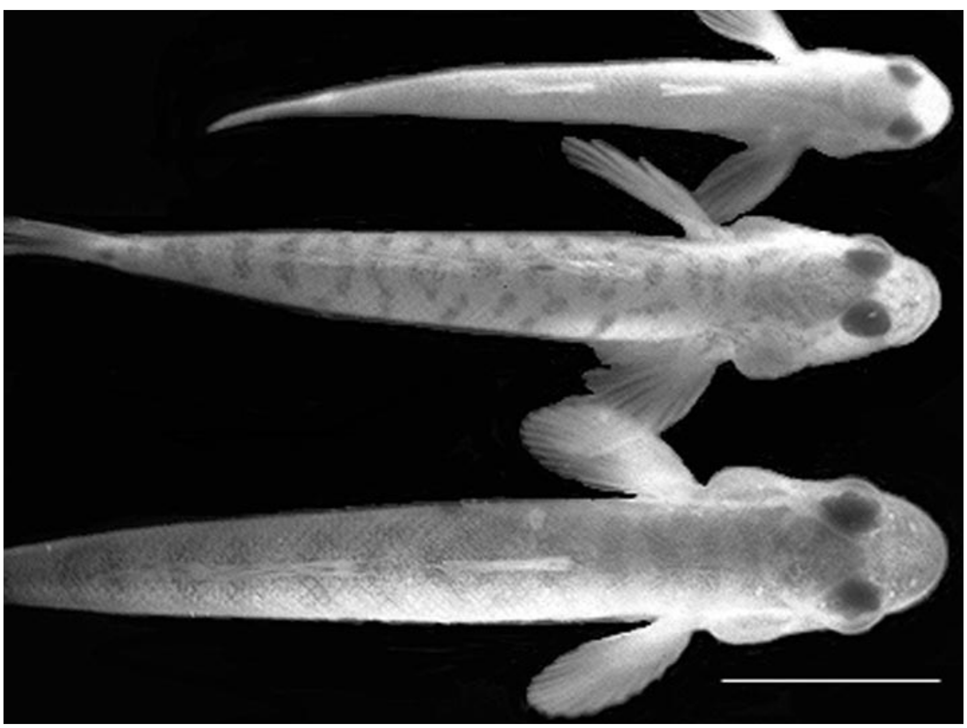

Figure 6. Postlarvae of (from top to bottom) *Lentipes concolor, Awaous guamensis* and *Sicyopterus stimpsoni* collected from 'I-ao Stream, Maui, Hawai'i. *Sicyopterus stimpsoni* is the largest, most darkly pigmented and has semi-circular snout, while *L. concolor* is the smallest, most lightly pigmented of these three species, and has the most pointed snout. The white scale bar represents 5 mm.

Regression Models and Discriminate Function Analyses

From the morphological measurements made on *L. concolor, A. guamensis* and *S. stimpsoni* we generated significant linear models to predict SL from TL, for use in field studies where handling or killing is not necessary. These models are presented in Table 3. Each species model was significant and there was not a significant difference between the slopes of the models (F = 0.011; d.f. = 2,52; p > 0.75). As far as we are aware these are the first, and only, allometric regressions for Hawaiian amphidromous fish postlarvae to be reported, and should prove useful in future studies aimed at minimizing postlarval handling of these species.

Results of the *a posteriori* discriminate function analysis are represented in Figure 7. All four Gobiidae species showed 100% correct classification among three significant discriminate functions; however, only the first two functions are plotted in Figure 7, as they sufficiently separate all species in two dimensions. Discriminate function #1 (Wilk's Lambda, U = 0.001, X^2 = 355.1, d.f. = 48, p < 0.001) separates all four species along the x-axis, where 13 of the 16 morphological variables were most highly correlated within this function (Figure 7). Among these 13 variables, TL showed the greatest absolute correlation with the following sequentially lower: SL, 2L, AL, PL, 1F, HL, 1L, BD, PD, PL, UL, UW. All of these were measures of length that would be expected to correlate allometrically with SL and TL, except for 1F ray number that separated *L. concolor* from all the other gobies in the dichotomous key. Discriminate function #2 (Wilk's Lambda, U = 0.033, X^2 = 176.9, d.f. = 30, p < 0.001) further separated *A. guamensis* and *S. hawaiiensis* from *L. concolor* and *S. stimpsoni* along the y-axis using PF ray number, which had a correlation coefficient of -0.406. Anal fin ray number (AF) and the second dorsal fin (2F) ray number were the most highly correlated variables in the third discriminate function (Wilk's Lambda, U = 0.483, X2 = 37.89, d.f. = 14, p < 0.001) providing additional separation between *A. guamensis* and *S. hawaiiensis.* Of these two variables, AF showed a higher correlation than 2F, with correlation coefficients of 0.382 and 0.303, respectively. These *a posteriori* results follow the dichotomous key and morphological distinctions made from the

Table 3. Linear regression models used to predict standard length (SL) from total length (TL), in mm, of *Lentipes concolor, Awaous guamensis* and *Sicyopterus stimpsoni* postlarvae.

	Lentipes concolor	*Awaous guamensis*	*Sicyopterus stimpsoni*
Equation	SL = (0.88)TL - 0.96	SL = (0.62)TL + 3.77	SL = (0.92)TL - 3.01
R^2	0.93	0.43	0.76
d.f.	19	19	17
N	20	20	18
F Ratio	223.5	13.4	51.8
p-value	< 0.0001	0.0018	< 0.0001

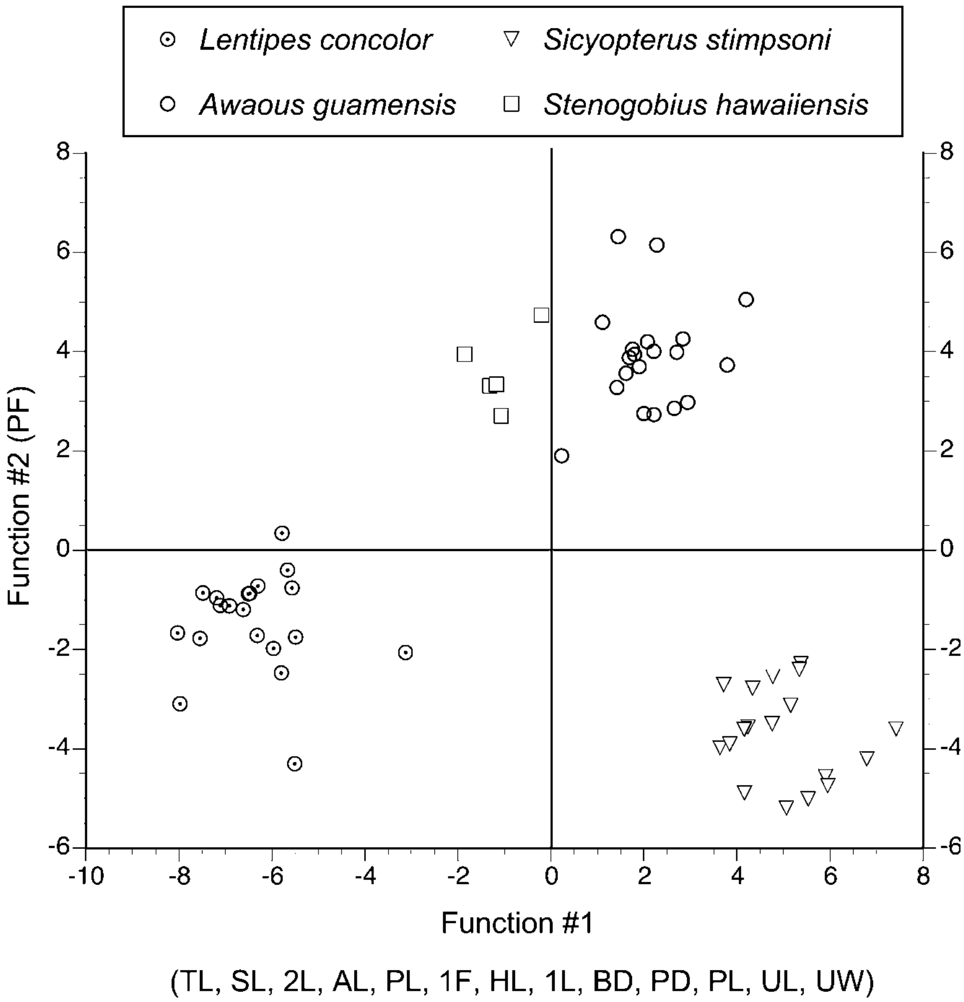

Figure 7. Results of the canonical discriminate function analysis showing the first two functions that separate all species along two dimensions. The first function is most highly correlated with SL and TL, and 11 other lengths that are allometrically related to SL, except for 1F (ray count) that separates *L. concolor* from the other gobies. Pectoral fin ray number (PF) is the most highly correlated variable in the second function and separates *S. stimpsoni* from the other gobies. A third function, with AF and 2F as the most highly correlated within the function, provides further separation of *A. guamensis* and *S. hawaiiensis.* The dashed lines are included to show the zero values and separation along each axis.

morphological means and modes, and indicate that morphological features alone can accurately discriminate between these species.

Conclusions

Documented anatomical differences are important for identification when specimens lose pigmentation after prolonged preservation. The results presented here indicate that the Hawaiian amphidromous goby postlarvae can be differentiated solely on morphometric characteristics. The presence/absence of fused pelvic fins, SL (along with TL), 1F, PF and AF were the most distinctive characteristics between all species as shown in the dichotomous key. Of the Gobiidae species (with fused pelvic fins), *S. stimpsoni* is the largest followed by *A. guamensis* and *L. concolor* and *S. hawaiiensis* as the smallest (Figure 6). The morphological data were confirmed using *a posteriori* discriminate function analysis, which separated the four gobies along three discriminate functions, where the most highly correlated variables within each function were the same morphological features used in each couplet of the dichotomous key.

Although these species can be separated morphologically, this may not always be practical (e.g., stream side surveys where specimens are identified live). It is with this understanding that we have provided Table 2, giving qualitative descriptions of each species, and also generated regression models to predict standard body lengths in the field. Ideally, the quantitative morphology and qualitative descriptions can be used together in order to provide a useful means of identifying freshwater Hawaiian postlarvae either in the field or after prolonged preservation (individually or grouped). Along with this dichotomous key, reported morphological characteristics and predictive regression models can be used in conjunction with keys based upon other anatomical descriptions of adults, postlarvae (e.g., Tate et al. 1992) and larvae (e.g., Lindstrom 1998). These tools will facilitate the collection of more comprehensive information on life history characteristics of the Hawaiian native stream fishes. An adequate understanding of native freshwater goby life histories is necessary for better stream management in Hawai'i. The amphidromous lifecycle makes this especially difficult. The ability to identify postlarvae under a variety of circumstances will aid in data acquisition important for understanding this life history strategy.

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