

Taxonomic Status, Biology, and Distribution of Hawaiian *Lentipes*, a Diadromous Goby¹

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ABSTRACT: Three species ascribed to the goby genus *Lentipes* include two from Hawaii, *L. concolor* (Gill 1860) and *L. seminudus* Günther (1880), and one from the Gulf of Guinea, *L. bustamantaei* Boulenger (1916). The Hawaiian species were described from single specimens of different sex. Specimens collected recently provide evidence that Hawaiian *Lentipes* comprise a single, sexually dimorphic species. The African species differs significantly and more nearly resembles *Sicydium*. *Lentipes* now must be considered a monotypic genus (*L. concolor*) endemic to the Hawaiian archipelago.

The genus is distinguished by weak scalation (2–150 cycloid scales per side on posterior trunk), five subequal and one shorter spine in the first dorsal fin, 16 pectoral rays, and one projecting ossified gill raker on the first arch. The sexes differ mainly in head shape, relative mouth size, dentition, spacing of dorsal fins, and coloration. The female is drab; the male is yellow to red posteriorly and has a white anal fin margin.

Adult *Lentipes*, omnivorous and growing to nearly 140 mm TL, inhabit pristine steep-gradient streams. Larvae develop in the ocean and appear at stream mouths as postlarvae less than 20 mm long. Upstream migrants are capable of ascending high waterfalls, where they reach areas of permanent residence. Surveys located *Lentipes* in 22 streams (6 percent of the total streams in the archipelago) but the goby was abundant in only a few of them. Because of sparse *Lentipes* populations and incompatibility with past and continuing habitat degradation, endangered status recognition is recommended.

TWO HAWAIIAN SPECIES OF *Lentipes*, family Gobiidae, have been recorded in the literature over the past century (Günther 1880, Ogilvie-Grant 1884, Jordan and Evermann 1905–1906, Gosline and Brock 1960, Miller 1972). They are *L. concolor* (Gill 1860) and *L. seminudus* Günther (1880). It is of particular significance to note that each of these species was described from a single specimen, a male *L. concolor* and a female *L. seminudus*. Apparently, the only other species referred to the genus is *L. bustamantaei* Boulenger, 1916, reported from islands in the Gulf of Guinea, Africa (Thys van den Audenaerde 1967).

Hawaiian stream fauna has been largely ignored scientifically until recent years. In 1966, the Hawaii Cooperative Fishery Research Unit began a continuing program on inland waters that included extensive collections and ecological studies. The two species of *Lentipes* appeared among early stream survey material. As collecting expanded into several streams on three islands, each species was observed to be monosexual, suggesting that the genus is represented by a single dimorphic species. This hypothesis was strengthened by correspondence from 1969 to 1972 with Dr. R. R. Miller and with Dr. J. M. Fitzsimons (who, on the basis of seven specimens he collected on Hawaii Island in December 1968, recognized the inadequacies of *Lentipes* descriptions).

Preliminary examination of 12 specimens (seven males, five females), for scalation and

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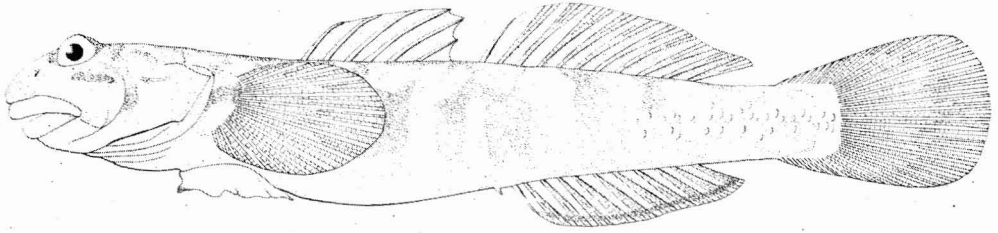


FIGURE 1. *Lentipes concolor* (Gill 1860) adult male. Composite drawing from five recently preserved specimens, 50 to 70 mm TL.

dentition, reinforced the single species hypothesis. More information was provided by Lau (1973), who analyzed 98 specimens of *Lentipes*. Subsequently, additional Hawaiian specimens were studied and comparisons were made with the African *Lentipes*.

This paper documents the taxonomic status and dimorphic features of Hawaiian *Lentipes* and describes its ecology, abundance, and distribution as elements to consider for its qualification as endangered (Miller 1972).

ANATOMICAL COMPARISONS

Original descriptions of the genus *Lentipes* (Günther 1861) and its two Hawaiian species (Gill 1860, Günther 1880) are terse and partly inaccurate in light of recent findings. Possibly, the authors intended only to distinguish these fishes from related Hawaiian taxa, especially the sympatric *Sicydium stimpsoni* Gill (1860). The best generic and specific descriptions are those of Ogilvie-Grant (1884), who apparently examined both holotypes of *Lentipes*. Key anatomical features in his descriptions are:

L. concolor: "The upper jaw has ten or eleven tricuspid, and about three conical teeth on each side of the maxillary suture.... Scales none.... The length of the pectoral is less than... the length of the head.... Both first and second dorsal fins are rather higher than the body; the latter has its origin considerably in front of the anal. Color uniform purplish, becoming almost yellowish on the tail. Anal fin with a darker marginal band."

L. seminudus: "The upper jaw has 15–16 tricuspid and about two conical teeth on each side of the maxillary suture.... The tail is covered with small cycloid scales.... The length of the pectoral greater than the length of the head.... Dorsal fins not so high as the body.... Color yellowish, reticulated with brown...."

Among 124 specimens of *Lentipes* collected during the past ten years from three islands (Hawaii, Kauai, Maui), only males conformed to the former description and females to the latter description. Sex was determined by shape of the genital papilla, and confirmed in most specimens by gonadal inspection. The following anatomical descriptions include both personal observations and those of Lau (1973):

Scalation

Small scattered cycloid scales are always present (a few to nearly 100 per side) but are limited to the posterior half of the trunk (Figure 1). Males usually have fewer total scales (2–120) than do females (20–150). In mature specimens, scales are thin, often imbedded, sometimes degenerate, and decrease in number with increasing body length.

Dentition

The upper jaw has an unspaced median row of replaceable tricuspid teeth adjoined laterally by a few irregularly spaced conical teeth. Males have 18 (16–21) tricuspids and 9 (5–17) large conicals distributed about

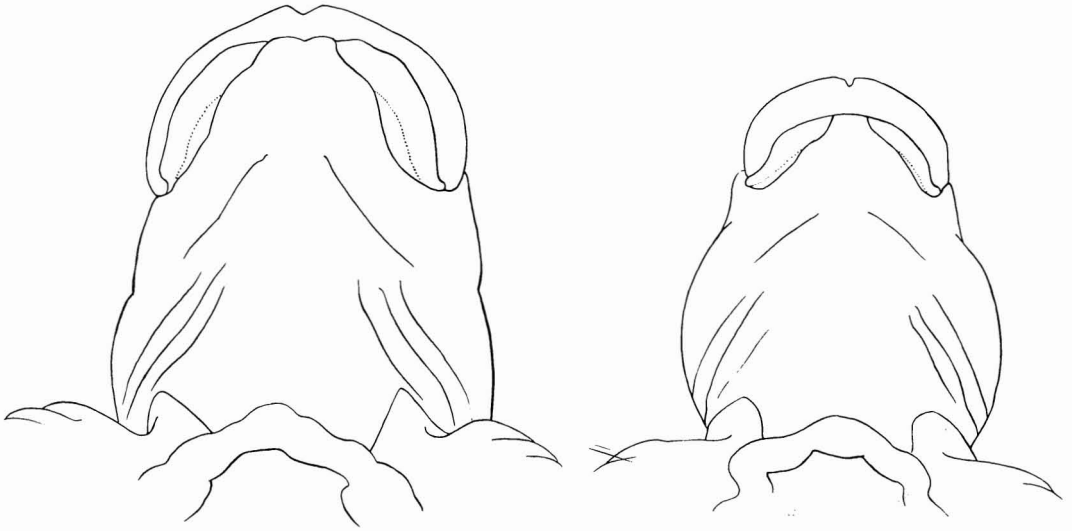


FIGURE 2. Heads of adult male (left) and female *Lentipes concolor* in ventral view. Sexual dimorphism is evident in head shape and mouth conformation. Dentition is also sexually dimorphic.

equally on either side of the midline. The females have 31 (27–40) tricuspid and 2 (0–4) small conicals. Gaps and regenerating teeth occur often in the tricuspid row; counts given include estimates of the numbers of missing teeth.

Head Morphology

Ogilvie-Grant (1884) noted slight size differences in the median notch of the upper lip and in head length relative to lengths of the pectoral fin and body. These variations indicate a fundamental difference in head morphology between the sexes. This difference is most obvious in comparing ventral views of heads of similar-sized individuals (Figure 2).

Dorsal Fins

Spacing of the dorsal fins (and to a lesser extent, their height) is a prominent sex-distinguishing feature (Figure 3). The second dorsal fin in the male is positioned nearer to the first dorsal than it is in the female because its origin usually is anterior to the vent. Fin spacing can be expressed as a ratio that overlaps slightly between the sexes. In 45 males,

interfin distance was contained an average of 38 (13–84) times in the standard length; in 29 females, the average ratio was 13 (9–17). In both sexes, ray count is D VI, I/10 (Figure 1); spines I through V of first dorsal are nearly equal in size (increasing slightly in length posteriorly) but VI is noticeably shorter than the others. Males have spines IV and V proportionately longer than those of females (Figure 3).

Coloration

Long-preserved specimens do not show the striking color differences that occur in living specimens. In life, the base body color of *Lentipes* is grayish- to olive-brown with darker irregular lateral spots that sometimes appear almost as dorsolateral bands (compare Figures 1 and 3). Females are drab, including all fins, but sometimes have small, variable, black spots along the dorsal midline that are not apparent in the male. Males, on the other hand, are drab only anteriorly; the posterior trunk, beginning at or slightly anterior to the vent, is dull yellow to bright red. All males become bright red caudally immediately after immersion in formalin. In addition, the anal fin of the male has a thin

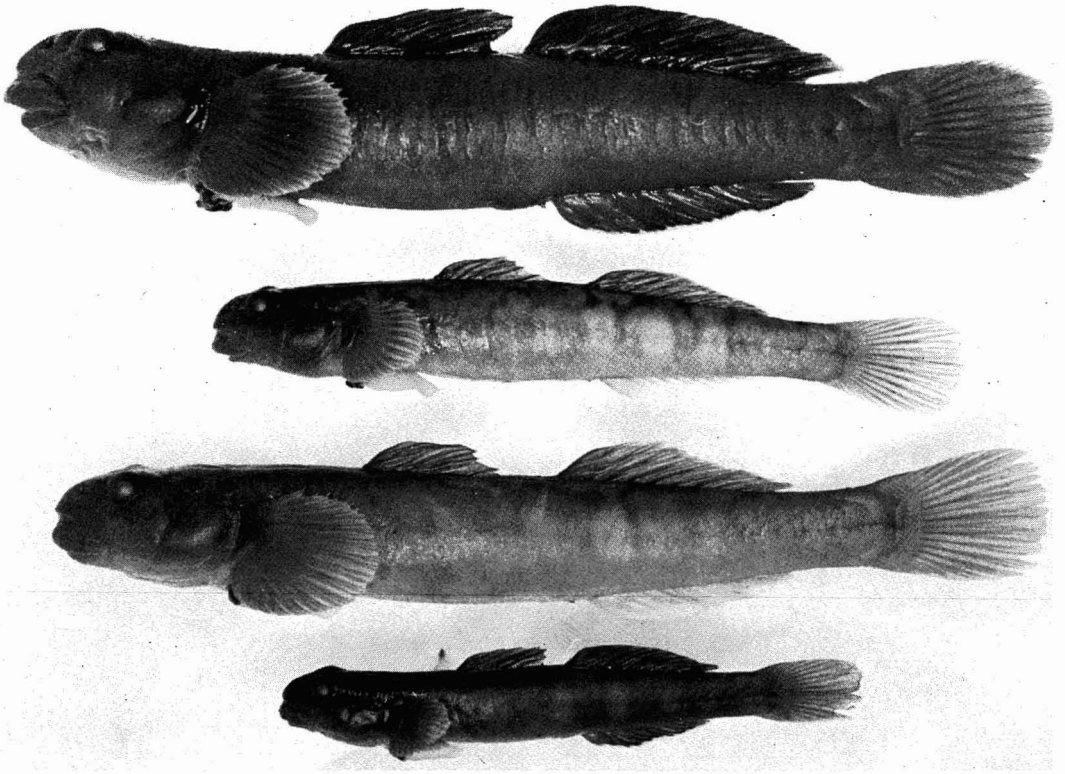


FIGURE 3. Photograph of preserved specimens of *Lentipes concolor*: males (top, bottom) and females (center pair). Sexual differences evident in lateral view include spacing of dorsal fins, shape of first dorsal fin, and coloration. Mottling of males is obscured by darker overall pigmentation that appeared mostly after preservation. Male posterior trunk, beginning at the origin of the second dorsal fin, is bright red.

white margin adjoined by a narrow black line (Figure 1). In situ color photographs and observations of males reveal a thin, light blue, iridescent margin on the caudal fin, dorsally and ventrally, which may be a transient color in courtship or spawning. Both sexes are translucent in life.

Length

Among *Lentipes* specimens exceeding 30 mm SL, 43 females averaged 53 mm and 52 males averaged 62 mm. The six largest specimens were males, as were eight of ten that exceeded 80 mm SL. Largest female and male *Lentipes* collected were 102 and 134 mm TL, respectively.

Other Features

Other meristic features observed that apply to both sexes are the following: pectoral fin rays (16, rarely 15 or 17); anal fin I/10; caudal fin rounded; and one projecting ossified gill-raker located on upper part of first gill arch (remaining gill arches have short papillar projections). Additional anatomical features were described by Lau (1973).

The African *L. bustamantaei* is a small goby (20–30 mm TL) described in detail by Thys van den Audenaerde (1967). Apparently, it was classified as *Lentipes* because of weak scalation, but in most other features, it does not agree with Hawaiian *Lentipes*. The most obvious divergent features of *L.*

bustamantaei are the following: 20 pectoral rays; rays of first dorsal variable in length; second dorsal with 11 or 12 soft rays; bilobed caudal fin; and no conical teeth in upper jaw. Thys van den Audenaerde (1967) described this species as “*Sicydium*-like fishes The species . . . sometimes . . . looks like young or neotenic *Sicydium*.” To me they strongly resemble postlarval *Sicydium stimpsoni* (Tomihama 1972) and *Sicydium plumieri* (Erdman 1961). After comparing both *Lentipes* species, Thys van den Audenaerde (personal communication, 4 March 1976) indicated that *L. bustamantaei* probably is not congeneric with Hawaiian *Lentipes* and perhaps constitutes a new genus related to West African *Sicydium*.

BIOLOGY AND DISTRIBUTION

Lentipes is diadromous as are most other prominent native Hawaiian stream animals. Only postlarvae and small juveniles appear to migrate actively upstream. These migrants demonstrate superb climbing ability and are known to surmount single waterfalls 100 meters high as well as a series of six falls surpassing 300 meters in combined drop. Mature *Lentipes* characteristically reside in middle to upper stream reaches at elevations from about 50 to more than 500 meters. They are not found near the coastline except in small precipitous streams. There is no evidence to indicate that this fish can tolerate brackish water once it has adapted to freshwater. According to Lau (1973), *Lentipes* is omnivorous, ingesting about equal amounts of algae (diatoms, filamentous chlorophytes and cyanophytes) and animal matter (aquatic insects, atyid shrimps, amphipods, and oligochaete worms).

Mature male *Lentipes* are strongly territorial and aggressive in the stream as well as in aquaria. Spawning apparently occurs in home territories where sexes are about equal in number. What was judged to be prespawning behavior has been observed in upstream areas. Although the spawning act of *Lentipes* has not been observed, it is assumed to be similar to that of other Hawaiian stream gobies (Tomihama 1972) that spawn in pairs

during rising or high water flows. Tiny, adhesive eggs, laid and fertilized in a monolayer on clean rock surfaces, hatch within a day or two. The hatchlings are carried passively in stream discharge to the ocean where they develop as marine plankton over a period of several weeks to months. They return to stream mouths as transparent postlarvae less than 20 mm TL. Pigmentation first appears after several hours in freshwater. Returning postlarvae of *Lentipes* have been collected in fall, winter, and spring, but never in large numbers. They differ from *Sicydium* postlarvae in being smaller and having squarish caudal fins. The smallest postlarva taken well inland from a stream mouth was 16 mm TL and pigmented.

Sex differentiation (based on genital papillae) is not evident in individuals smaller than 30 mm TL. Females mature when about 50 mm long. Ripe females have been captured from August to May, suggesting that spawning might occur year-round (depending upon freshets) and possibly peak in early fall with the onset of the wet season. *Lentipes* is relatively fecund, as are other insular diadromous animals. Two ripe females examined, 46 mm and 57 mm TL, contained about 7,000 and 14,000 eggs, respectively. The eggs were similar to those of *Sicydium*, slightly oval and 0.3 to 0.4 mm long.

The two specimens of *Lentipes* described before 1900 were from streams at Hilo, Hawaii, and Honolulu, Oahu. *Lentipes* has not been seen or collected on Oahu in recent decades. It was reported in 14 of 145 streams surveyed between 1960 and 1968: seven on Hawaii, two on Kauai, and five on Maui (Hawaii Division of Fish and Game, Federal Aid project annual reports). Later surveys located *Lentipes* in eight additional streams: two on Hawaii, four on Maui, and one each on Kauai and Molokai (Hawaii Cooperative Fishery Research Unit unpublished data). The 22 known habitat streams represent about 6 percent of the total perennial streams (360+) in the archipelago. Most streams having *Lentipes* are small and are located on relatively young (Pleistocene) landmasses such as East Maui and the windward slopes of Mauna Kea (Hawaii).

Rarely has *Lentipes* been observed in abundances approaching those of other diadromous stream animals. The only large populations observed by the author were in Hanawi Stream (East Maui) and Wailau Stream (Molokai). Hanawi is unusual in that most of its flow emanates from a large spring that is several degrees cooler than typical stream water (15° C versus 19–20° C). In some small streams, *Lentipes* is the only fish found. Elsewhere, it appears to coexist only with *Sicydium stimpsoni*, a grazing herbivore (Tomihama 1972). Whether returning post-larvae are capable of selecting habitat streams is questionable. There is no evidence of homing; anatomical uniformity of specimens from different localities (islands) suggests genetic mixing.

HAWAIIAN LORE

Aboriginal Hawaiians developed a system of faunal names roughly comparable to modern scientific nomenclature. Hawaiian fish names are still in use, especially for species having no other common names. Gobioid fishes are called *o'opu*, collectively (Titcomb 1972). *O'opu-wai* are freshwater gobioids, in contrast to *o'opu-kai*, their marine kin. *Hinana* are the postlarvae of diadromous gobioids that appear at the mouths of streams in the initial phase of upstream migration.

Each species of *o'opu-wai* has one or more distinguishing names (Titcomb 1972). *Lentipes* is referred to variously as *o'opu-hi'ukole* (raw-tailed), *o'opu-hi'u'ula* (red-tailed), and *o'opu-alamo'o* (lizardlike). Inasmuch as the first two names apply only to males, and the lizard association probably applies to both sexes, the suffix *alamo'o* appears to be the most appropriate single common name for the genus.

Lentipes was "... *kapu* to many Hawaiians because of their belief that it is related to the *mo'o* gods" (Titcomb 1972). It was treated either with fear or disgust because it represented *mo'o* (lizard), an animal with powers of evil. According to Titcomb, it is bad luck to find *alamo'o* in one's net while fishing

"... for it keeps other fish away and must be thrown out of the net with an exclamation of disgust if one expects to be successful. . . ."

DISCUSSION AND CONCLUSIONS

The description of two species of Hawaiian *Lentipes* a century ago is understandable considering that the descriptions were based solely on long-preserved single specimens of different sexes. Recent studies of numerous specimens from various locations, together with ecological observations, now show clearly that only one dimorphic species is present in Hawaii. It would be of interest to compare the holotypes with recent findings. This was attempted by R. R. Miller, who examined the holotype of *L. seminudus* (BMNH 1879.5 14:581) and found it in extremely poor condition (personal communication, 8 September 1971). He attempted, without success, to locate the holotype of *L. [Sicyogaster] concolor*. The loss of the latter holotype is unfortunate because Gill's nomenclature (Gill 1860) as amended, viz. *Lentipes concolor* (Günther 1861), takes precedence for the Hawaiian species.

The third species (African) evidently does not belong in the genus inasmuch as it bears no close resemblance to the Hawaiian *Lentipes*. Here, the Hawaiian *Lentipes* is considered a monotypic genus endemic to the Hawaiian archipelago. Below is a redescription of *L. concolor* based on valid parts of the original descriptions and expanded by other characteristics found in this study, including dimorphism.

Description

Body subcylindrical; anterior naked, posterior with small, scattered, cycloid scales sometimes few and indistinct. Head oblong, depressed; cleft of mouth horizontal; snout obtusely rounded with one notch (medial) in upper lip. Jaws subequal; a single series of fixed teeth in both jaws; lower with numerous, short, widely set, pointed, horizontal teeth; upper with closely set tricuspid teeth medially and widely set conical teeth laterally. Fins:

dorsal VI, I/10, the first five spines of anterior dorsal subequal, the sixth noticeably shorter; caudal rounded; anal I/10; pectorals 16; ventrals united into a short disk, adherent to the belly. Five branchiostegal rays; one projecting ossified gillraker near top of first gill arch; remaining arches with papillar projections only. Sexes dimorphic as follows:

FEMALE: Adult with bilobed genital papilla; body color in life entirely grayish brown to olive brown with darker mottling; fins drab; dorsal fins widely spaced, the interfin gap contained fewer than 15 times in the standard length; head subtrapezoidal in ventral view, mouth much narrower than the greatest head width; upper jaw with 31 (27–40) tricuspid and 2 (0–4) small conical teeth; maximum TL recorded, 102 mm.

MALE: Adult with pointed genital papilla; body color in life brownish anteriorly and pale yellow to bright red posteriorly, mottling weaker than in female; anal fin with narrow white margin and a thin black line submarginally; dorsal fins closely spaced, the interfin gap contained more than 15 times in the standard length; head subrectangular in ventral view, mouth nearly as wide as greatest head width; upper jaw with 18 (16–21) tricuspid and 9 (5–17) conical teeth; maximum TL recorded, 134 mm.

Designating *Lentipes* as a Hawaiian endemic raises the question of whether it might occur elsewhere, such as other high islands in Polynesia and Micronesia where stream fish collections have been scant. Polynesia seems the less likely of the two regions, partly because of hemisphere watermass separation and partly because of inferences in Hawaiian lore. Early Hawaiians readily accepted as food other stream gobioids similar to species of their native Polynesia. The aura of trepidation or disgust with which the Hawaiians viewed *Lentipes* suggests that it was a strange fish to them, unlike any in their homeland. If *Lentipes* occurs elsewhere, it might be found in the North Pacific Micronesian archipelago, the Caroline Islands.

Characteristic habitat streams are precipitous, pristine drainages usually on geologically new landmasses. *Lentipes*, broadly omnivorous, resides mainly in upstream areas

and does not co-occur with other fishes except the herbivorous *Sicydium*. Together, these factors indicate that *L. concolor* is a pioneer species adapted to colonize streams as they first appear geologically. Furthermore, *Lentipes* is much less common than other Hawaiian stream gobioids. Its reported occurrence in 22 streams is not intended to imply that all inhabited streams have viable populations. Reports, in some instances, were based on observation or collection of one or a few individuals indicative of marginal populations dependent on reproduction elsewhere. Vigorous, sustaining populations of *Lentipes* are known only in a few streams such as Hanawi. It is probable that critical habitat streams are fewer than half the total number of streams in which *Lentipes* resides.

Substantial inventories of Hawaiian streams and their faunas have been made only during the past two decades. Even in that relatively short time, depletion and disappearance of populations of native stream animals have been observed in several streams. One example is the loss of *Lentipes* from Piinau Stream (East Maui) in 1972 concurrent with the establishment of a riparian arboretum. *Lentipes*' disappearance from Oahu and its sparse distribution on the remaining islands reflect the attrition of natural stream quality that has been noted elsewhere (Maciolek 1975). Degradation of stream environments has resulted mainly from water diversion and the establishment of exotic species, abetted by channel modification and contamination. Only a small fraction of the streams in the State retain a relatively pristine character. Oahu's streams have suffered most severely; their faunas are now dominated almost completely by exotic species.

Degradation of Hawaiian stream environments continues with economic and population growth; dewatering increases with socioeconomic demand. Only one Hawaiian stream ecosystem (not known to have *Lentipes*) is attaining protected status. *Lentipes concolor*, one of the world's unique gobies, is not compatible with these changes. It is clearly in jeopardy. This species, perhaps more than any of several other depleted endemic Hawaiian stream animals, should

be accorded recognition as endangered so that action can be taken to perpetuate it. This is being proposed in the forthcoming IUCN Red Data Book (R. R. Miller, personal communication, 6 August 1976).

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