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Drizzle Lake
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The following is the final report on research conducted by Elizabeth Stinson on the Drizzle Lake Ecological Reserve, Queen Charlotte Islands, British Columbia between Apr , 1981 and August, 1982. This report is filed in accordance with section 10 of the regulations for Ecological Reserves in British Columbia (B.C. Reg. 335/75).

Objective

The objective of this research was to identify the mechanisms working to maintain the morphological differences between two forms of the threespine stickleback (*Gasterosteus aculeatus*) found in Drizzle Lake and its inlet respectively.

Methodology

1. Field study of the inlet form to determine population size and patterns of distribution and movement within the stream as well as between the stream and the lake. Standard capture-mark-recapture techniques were used for this study. Fish were trapped in minnow traps, marked by fin and spine clipping or by the placement of a rubber band on one of the spines, and released.

2. Extension of the morphological analysis of the lake and inlet forms already undertaken by Dr. T.E.Reimchen. Additional characters, particularly in the head region, were included. Also, a morphological study of inlet stickleback from along the stream was undertaken to look for clinal variation of any kind. Measurement and meristic data collection, followed by regression of these data on distance from the stream mouth were used.

3. Mate-preference tests (male-choice, lake males only) were conducted *in situ* to determine whether some degree of non-random mating (sexual or ethological isolation) was involved. Plastic models of gravid lake and inlet females were then used to determine whether one visual aspect of the female (size or colour) served as a stimulus for the male during courtship. Nesting lake males were presented with a choice of captive live females (mate-pref.) or model females (model-pref.) and their responses were observed by a snorkelling diver.

4. Habitat-preference tests were run to establish whether any single variable,

of several that were tried, could be used as a cue by either of the two forms to limit them to their respective habitats. Univariate choice experiments using light, current, vegetation, etc. were conducted in aquaria of two sizes and a Y-shaped plexiglass tank. Time spent in each of the two alternatives in each experiment was recorded.

5. An evaluation of the food habits of both forms based on stomach contents analysis was compared to rough estimates of invertebrate densities in the two habitats. Experiments to test the abilities of the two sticklebacks to consume alternate prey items were not successful.

Floral and Faunal Inventory

The table (attached) which compares the lake and stream habitats is taken directly from my M.Sc. thesis on the sticklebacks of these areas. With the exceptions of the liverwort (*Scapania*) and the clam (*Pisidium*) no species of plants or animals were identified which had not previously been noted and described by Sheila Douglas or Dr. T.E.Reimchen.

Landforms and Soils

Landform and soil conditions within the Drizzle Lake Ecological Reserve were not assessed in the course of this study, except for those soils which made up the substrates of the lake and stream themselves. Substrates in the lake included soft organic ooze, fine sand, sand-gravel combinations (often compacted into cement-like sheets), cobbles with and without sand, and large rocks. In the stream, the bottom consists of coarse sand midstream with areas of organic ooze in backwaters and at the outside corners of the stream where current is reduced.

Results

Only a brief summary of the results of this research is presented here. A copy of the thesis resulting from this work with a complete account is on file with the Ecological Reserves Unit.

1. The estimated population size of inlet stickleback in the summer of 1981 was 550 fish in the adult (third summer) and subadult (second summer) age classes. These fish were confined to the lower 450 m of the 4500 m stream; the upper limit of their

distribution was marked by two small waterfalls. An increase in movement of subadult fish was apparent in the fall. Lack of movement earlier in the year was attributed to the involvement of adults in reproductive activities.

2. Threespine sticklebacks found in the inlet differ morphologically, ecologically, and behaviourally from their counterparts in the lake itself.

3. Inlet sticklebacks are shorter and deeper bodied than lake fish and have relatively shorter spines and larger heads. Eye diameter of the inlet fish is greater. Differences found in other head characters (snout length, cheek height, interorbital width) may be related to the differences in eye diameter, but selection favouring the retention of juvenile characteristics in the inlet adults may be involved.

4. There is little contact between breeding individuals of the two forms of stickleback. Ecological isolation may have resulted from different habitat preferences. Inlet fish responded positively to inlet water and to moving water. Vegetation type evoked the strongest response from the lake fish tested as they preferred that typical of the lake habitat.

5. Temporal isolation is not a factor in reducing gene flow between these two groups. A comparison of the timing and length of the two reproductive seasons revealed an almost complete overlap in spawning period of the females.

6. Lake males approached lake females approximately 70% of the time. When presented with plastic models which differed in size or colour pattern, lake males approached the black (lake-coloured) models significantly more often than brown (inlet-coloured) ones. The black colour was found to be a stronger stimulus than the larger size of the lake females.

Conclusions and Recommendations

Ecological and ethological isolating mechanisms are in effect between the inlet and lake forms of the threespine stickleback in Drizzle Lake although neither mechanism is absolute. Lake fish were occasionally trapped in the inlet; inlet males (3) have been collected in the lake, 300 m from the mouth of the inlet. Inlet females responded positively to the approaches of the lake males in the mate-preference tests. Thus, matings between the two forms are possible, though unlikely. According to widely accepted definitions of "good" biological species, two potentially interbreeding groups between which breeding has been reduced are "good" species. The lack of individuals with morphological characteristics intermediate between the two forms suggests that, in fact, no successful interbreeding is taking place. One or more post-mating mechanisms (zygotic mortality or hybrid inviability) are presumed to be operating.

Threespine sticklebacks in the Drizzle Lake drainage are not unique in the degree of divergence that has taken place between lake and stream forms. A similar situation is known to exist in the Mayer Lake drainage on the Charlottes and may occur in other watersheds with similar geomorphological and biotic features (e.g. bog lakes with similar predator populations). At present, the question remains whether the morphological divergence occurred while the lake and stream forms were geographically isolated (in allopatry) or as a result of selection acting on a single population such that two forms were produced adapted to two niches (in sympatry). Further comparison of the Drizzle Lake stickles to those of neighbouring lakes (e.g. Skonun) and streams, and to the anadromous threespine stickleback which spawns in the Sangan River may help answer the historical question.

Most studies of speciation and the factors leading to it are conducted in laboratories where most variables can be controlled. There is often some uncertainty as to how those laboratory data can be related to events taking place in natural populations. The Queen Charlotte Islands _in toto_ offer a natural laboratory, still relatively undisturbed by man, where hypotheses generated under more controlled conditions may be tested.

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Table I

A Comparison of Lake and Inlet Habitats During the Breeding Season (May - August), 1982

	Lake	Inlet
Physical		
Temp (°C)	16.98(11.0-19.5)	10.95(5.17-15.3)
pH	4.71(4.55-4.85)	5.66(4.45-6.65)
Water colour	medium tea colour	dark tea colour
Transparency (Secchi disc-cm)	133.07(117.5-142.0)	60.5(40.5-80.5)
Bottom	fine sand, hard-packed sand/gravel	coarse sand, ooze along banks and in backwater
Biotic		
Vegetation	*Juncus* sp., Unidentified, filamentous alga, *Scapania* sp., *Lilaeopsis occidentalis*, *Eleocharis* sp., *Nuphar luteum*, *Sphagnum* spp.	*Sphagnum* spp., *Juncus* sp., Unidentified, filamentous alga,
Vertebrates Fish	*Gasterosteus aculeatus*, *Salmo clarki*, *Salvelinus malma*, *Oncorhynchus kisutch*	*G.aculeatus*, *O.kisutch*, *S.malma*, *S.clarki*
Amphibians	*Bufo boreas*, *Hyla versicolor*	*B.boreas*, *H.versicolor*
Invertebrates Benthic	Chironomidae, larvae of Trichoptera, Lumbriculidae, nymphs of Odonata	Gammaridae, Chironomidae, Mollusca (*Pisidium*), Lumbriculidae, nymphs of Odonata (Aeshnidae, Libellulidae, and Zygopteran), larvae of Trichoptera and other Diptera
Planktonic	Cladocera (Bosminidae, Chydoridae), Copepoda (*Cyclops*), Hydracarina	Rotifers, Chironomidae, Cladocera (Chydoridae, Bosminidae), Copepoda (*Polyphemus*, *Cyclops*), copepod nauplii, *Chaoborus*
Plankton density (approx.)	$3900/m^3$	$54/m^3$

Notes: -Physical characteristics are average conditions with range in brackets.

-Floral and faunal composition listed in order of abundance within each category.

-Area of the lake considered is that bordering the inlet mouth and extending for 125 m. along lakeshore.