

Status of Unarmoured and Spine-deficient Populations (Charlotte Unarmoured Stickleback) of Threespine Stickleback, *Gasterosteus* sp., on the Queen Charlotte Islands, British Columbia*

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Endemic populations of the Threespine Stickleback (*Gasterosteus aculeatus*) with major loss of spines and lateral plates and tolerance to naturally acidic waters occur in three small lakes in the Sphagnum dominated lowlands of the Queen Charlotte Islands, British Columbia. Recent range extension of the Beaver (*Castor canadensis*), an introduced species on the islands, has resulted in increased water levels and organic debris in two of the lakes. Population numbers of stickleback appear to be stable, although the increase in organics may influence the reproduction of the fish. Introduction of Cutthroat Trout, *Salmo clarki*, a predator on stickleback, could seriously decrease numbers in these small populations, or, more likely, significantly modify their genetic structure. These populations can be categorized as "rare".

Des populations endémiques d'épinoches à trois épines (*Gasterosteus aculeatus*), qui ont perdu la majorité de leurs épines et de leurs plaques latérales et qui tolèrent l'acidité naturelle des eaux, peuplent trois petits lacs des basses terres des Iles Reine-Charlotte (Colombie-Britannique) où pose surtout la sphaigne. La montée des niveaux d'eau et l'accumulation de débris organiques dans deux de ces lacs sont le résultat des activités du castor (*Castor canadensis*), une espèce nouvellement venue dans les Iles, dont la répartition s'est étendue récemment. Le nombre d'épinoches semble être stable, quoique l'accumulation de débris organiques puisse influencer sur la reproduction de ce poisson. L'introduction de *Salmo clarki*, un prédateur de l'épinoche, pourrait entraîner une diminution importante de ces populations déjà peu nombreuses, mais plus probablement modifier leur structure génétique de façon importante. Ces populations entrent dans la catégorie "rare". [Traduit par R. R. Campbell].

Key Words: British Columbia, Queen Charlotte Islands, Boulton Lake, Rouge Lake, Serendipity Lake, sticklebacks, rare, distribution.

On the Queen Charlotte Islands, British Columbia, the Threespine Stickleback (*Gasterosteus aculeatus*) displays extensive morphological variation between populations (Moodie and Reimchen 1973, 1976; Moodie 1984). Since 1976, some 120 lakes from remote localities on the islands have been sampled in order to provide a description of the species variability throughout the archipelago. The present report describes three endemic populations which diverge markedly from other populations.

The common freshwater form of the stickleback normally has three dorsal spines, an anal spine, two pelvic spines and a series of lateral bony plates. These characters are of prime importance in defense against vertebrate predators (piscivorous fish and birds). The three populations discussed here are exceptional in that they show major reduction, or loss, in these characters, as well as reduction in numbers of fin-rays and in other bony elements (Figure 1). There are reasonable grounds for assuming that lateral plate and spine differences are genetic traits, while fin-ray variation is influenced both by temperature and inheritance (Lindsey 1962).

Distribution

The three lakes (Boulton, Rouge and Serendipity) are located in the Queen Charlotte lowlands, an expanse of bog and coniferous forest that dominates the northeast corner of Graham Island (Figures 2 and 3). Other than those on the Queen Charlotte Island, Threespine Stickleback with comparable morphologies have been reported from one lake on Texada Island, British Columbia (J. D. McPhail, personal communication) and several lakes in California (Miller 1960) and the Outer Hebrides in Scotland (Campbell 1979).

Protection

Threespine Stickleback have no formal protection; they are common and widely distributed in a diversity of habitats. However, some populations with divergent fish have been given protected status, including the large, Black Stickleback from Mayer Lake (Moodie 1984), Queen Charlotte Islands (an Ecological Reserve), and the plateless *G. aculeatus williamsoni* in California.

*Rare status approved and assigned by COSEWIC 6 April 1983.

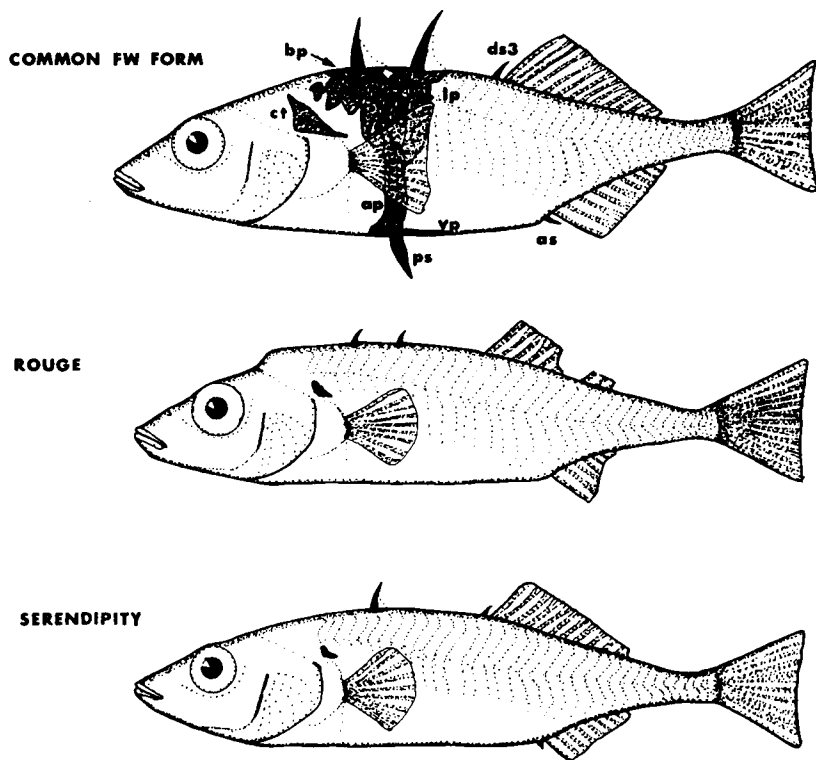


FIGURE 1. Representative specimens of *Gasterosteus aculeatus*. Boulton Lake stickleback (not shown) similar to those from Serendipity Lake. ap = ascending branch of pelvic skeleton, as = anal spine, bp = basal plate of dorsal spine, ct = cleithrum, ds3 = third dorsal spine, lp = lateral plates, ps = pelvic spine, vp = ventral plate of pelvic skeleton. Magnification X2.

Population Size and Trends

Total numbers of fish in each lake have not been determined; however, it was possible to obtain crude estimates of density by using a range of sampling techniques. Such estimates give a total population of 350 000 for Boulton Lake; 17 500 for Rouge Lake; and 22 000 for Serendipity Lake. As assessed from trap success (numbers of fish per trap hour), there had been no obvious changes in the abundance of fish during the sampling period (Boulton: 1970-1981; Rouge: 1976, 1978, 1980, 1981; Serendipity: 1979-1981). The expansion of the Beaver (*Castor canadensis*), as discussed below, may have an adverse effect on population numbers in the future.

Habitat

The broad characteristics of the three small lakes are summarized in Table 1. The watersheds are not connected and have separate drainages to marine waters. Each lake is surrounded by Sphagnum bog

and scrub coniferous forest; these watersheds are similar to adjacent areas where lakes with "normal" stickleback are found. In the last 20 years, the natural drainage system in the area has changed due to the activities of the Beaver.

Beaver were introduced onto the Queen Charlotte Islands by the British Columbia Game Commission in 1949. Since that time, they have extended their range throughout much of Graham Island. In the lowland region, the alteration of habitat has been extensive. Water levels have risen, resulting in submergence of large areas of Sphagnum bog and inundation of cedar forest. Previously isolated lakes have been connected and small creeks where Coho Salmon (*Oncorhynchus kisutch*) are found have been blocked. It is primarily the small lakes and ponds (≤ 20 ha) which have been adversely affected. Aerial photographs from 1937 to the present show a loss of the sandy littoral areas in several lakes since the mid-1950's and a general increase in the surface area of others.

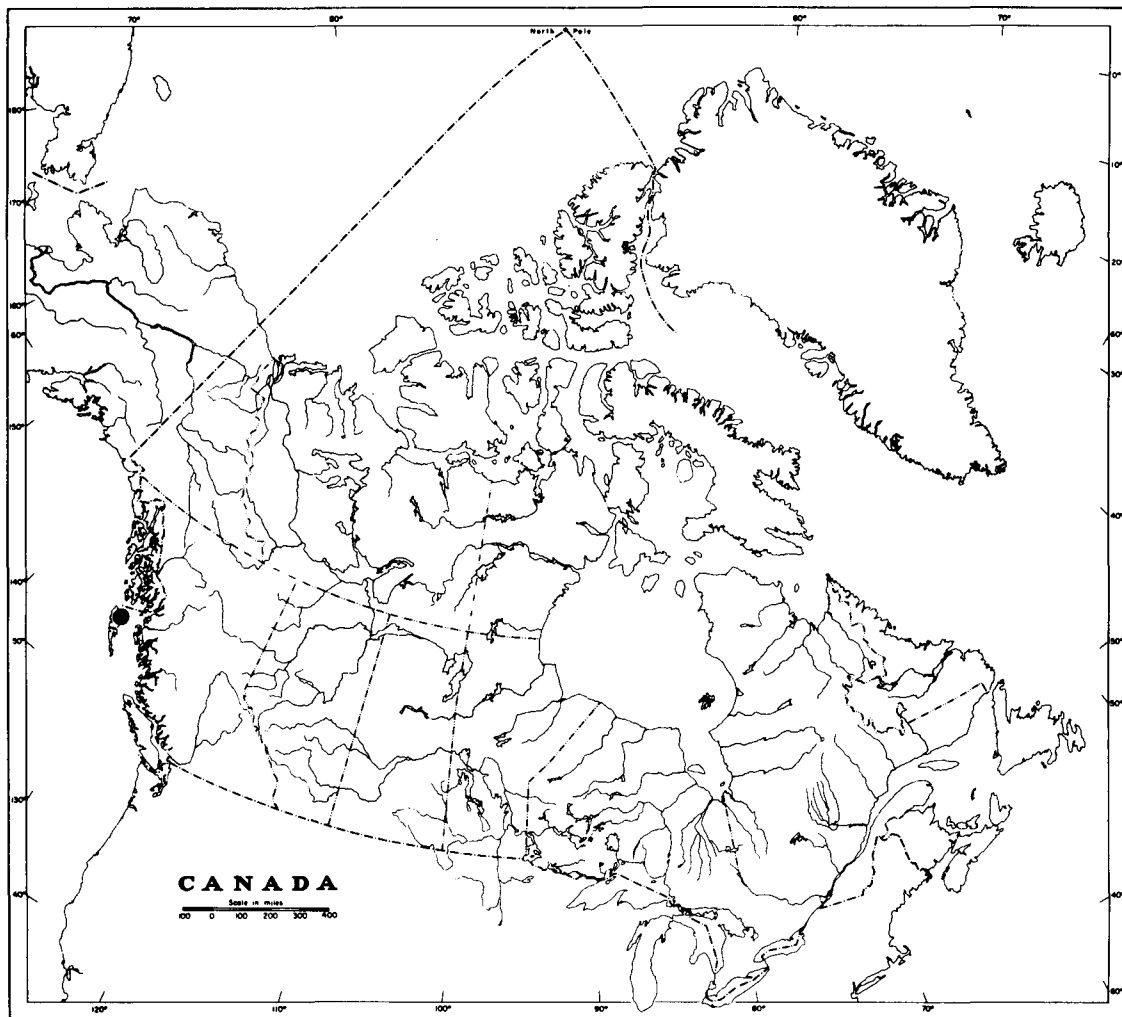


FIGURE 2. Distribution of Unarmoured Stickleback (*Gasterosteus* sp.) in Canada. Courtesy of D. E. McAllister National Museum of Natural Sciences.

Habitat Trends

Boulton Lake. There have been no significant changes in water levels or in the lake basin between 1970 (when the lake was first visited) and 1981.

Rouge Lake. In 1970, when this lake was first sampled, the shoreline was characterized by broad sand beaches which extended to the edge of vertical Sphagnum banks. Breeding stickleback were observed throughout this shallow area. Between 1970 and 1975, Beaver gained access to the watershed and blocked the outlet stream. This resulted in a 0.5 to 1 m increase in the lake level, with a subsequent elimination of the shallows. Dead Sphagnum from the banks

and Lodgepole Pine (*Pinus contorta*) have fallen into the lake. The sand substrate, although still present in some microhabitats, is now largely covered with a layer of these organics. Furthermore, since the water is extensively stained (from humic acids), only a small amount of light penetrates to the bottom of the lake and higher water levels have decreased the photic zone near the shore. Some of these factors have already led to an irreversible change in the fish population. In 1970, breeding male sticklebacks had very well-developed red throat pigmentation, yet this has not been observed in any fish collected from 1978 to the present. Dolly Varden (*Salvelinus malma*) were com-

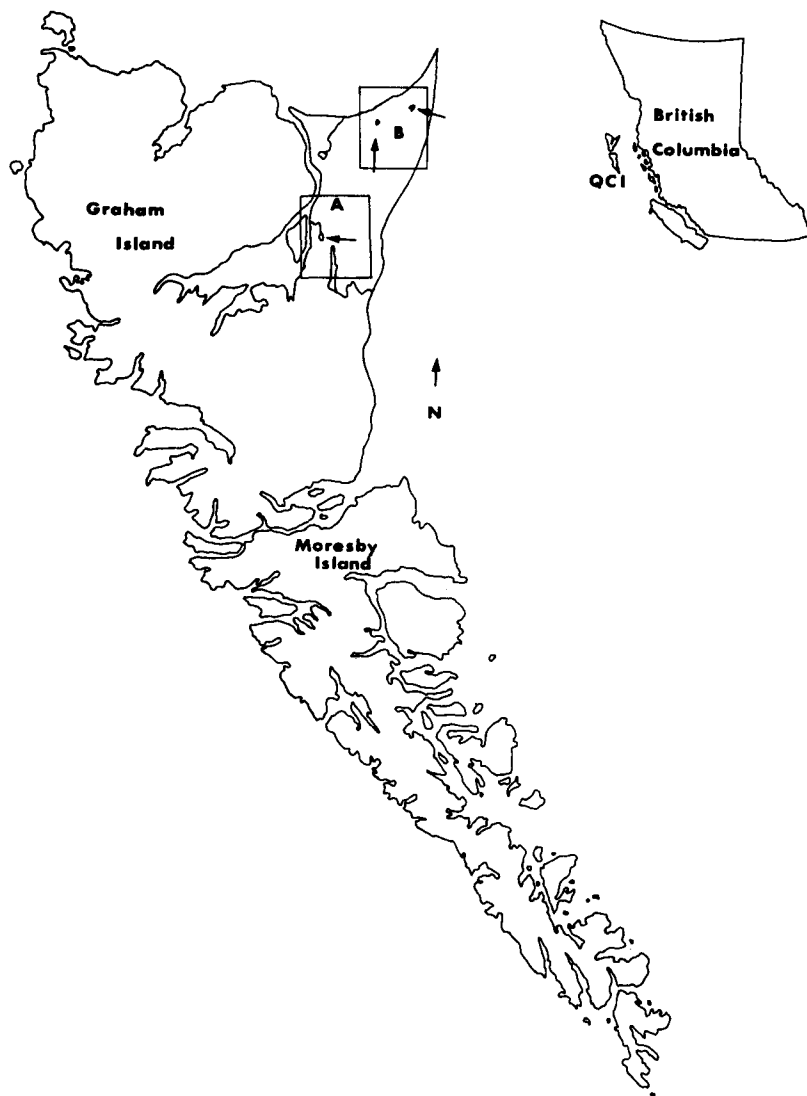


FIGURE 3. Range maps of Unarmoured Stickleback (*Gasterosteus* sp.) on the Queen Charlotte Islands. Block A shows Boulton Lake, Block B shows Rouge and Serendipity Lakes.

mon in the lake in 1976 and 1978, but were not observed during two visits in 1981. This may be a sampling artifact and will require confirmation. Rouge Lake, while going through a period of rapid change in the 1970's, appears now to have a stabilized water level.

Serendipity Lake. The habitat changes in this lake are similar to those of Rouge Lake, except that Beaver were first observed in 1979; by 1981, there had been a 0.5 m increase in the lake level and a 30 per cent increase in the surface area. Most of the former Sphag-

num banks are submerged and a 2 ha conifer stand near the former outlet is inundated. There has been a fall in pH from the mid 4's in 1979 to 3.90 in 1981, a possible result of flooding of the Sphagnum bog.

Protection of habitat

Boulton Lake. The lake and watershed lie on crown land within walking distance of the single Island highway. Although there is some local awareness that the lake contains unusual fish, this is offset by growing pressure for recreational areas, which may include

TABLE I. Habitat description of Boulton, Rouge and Serendipity Lake, Queen Charlotte Islands, British Columbia

Parameter	Boulton	Rouge	Serendipity
Size (ha)	18	1.7	2.2
Maximum depth (m)	4.2	2	2
pH	4.7	(estimated) 4.1-4.5	(estimated) 3.9-4.3
Water colour	clear	stained	stained
Substrate	sand, gravel, organic ooze	sand, organic ooze	organic ooze
Water source	<i>Sphagnum</i> see page 121	
Outlet	intermittent	closed (beaver dam)	closed (beaver dam)
<i>Nuphar luteum</i> cover (%)	10	50	50
Surrounding vegetation	<i>Sphagnum</i> <i>Pinus</i> <i>Thuja</i>	<i>Sphagnum</i> <i>Pinus</i>	<i>Sphagnum</i> <i>Thuja</i> <i>Chamaecyparis</i>
Fish species	<i>Gasterosteus</i>	<i>Gasterosteus</i> <i>Salvelinus malma</i>	<i>Gasterosteus</i>

introduction of trout for the sports fishery. As well, proximity to the road makes the lake sensitive to future rural and industrial activities. During the last three years, logging operations have increased in adjacent watersheds.

Rouge Lake. This lake is located on a 130 ha private holding within Naikoon Provincial Park. One of the land owners intends to develop his holding for small-scale agricultural use if, and when, road access rights through the Park are approved. Presently, Parks' authorities have not granted a permit for such road access and the lake remains undisturbed (apart from Beaver activity).

Serendipity Lake. This watershed is within Naikoon Provincial Park and thus rural and industrial development are excluded.

Degree of specialization

Rouge and Serendipity Lakes are in an advanced stage of bog succession with overhanging banks of *Sphagnum* and major cover by *Nuphar luteum*. The extreme reduction of defensive traits is probably intimately related to this successional stage, since fish predators and large avian piscivores are excluded from the system, either by the acidic conditions or the small size of the lakes. Increased surface area of Rouge and Serendipity Lakes, due to beaver activity, will result in a greater utilization of the lakes by predatory birds such as loons (*Gavia immer* and *G. stellata*) which are abundant in this region (Reimchen and Douglas 1980).

General Biology

The sticklebacks in these lakes have a breeding structure similar to other populations of sticklebacks. Sex ratio is close to equality, females produce from

100-300 eggs, and breeding occurs in the third year, after which post-reproductive individuals die. In each lake, large numbers of fry have been observed. While numbers of fish appear to be similar each year, I suspect that, at Rouge and Serendipity Lakes, the increased organics on the lake bottom and reduced light transmission onto the nesting areas could adversely affect nest construction and reproductive success. Anaerobic conditions prevail very close to the surface layer of organic debris in bog pools (Moore and Bellamy 1974) and could suppress egg development in nesting stickleback.

The sticklebacks spend their entire life within the lake. Fry and adult males are found primarily near shore in spring and summer and move into deeper water during winter months. Females and sub-adults occur in open water near the surface during summer and in benthic regions in winter.

Limiting Factors

There are several factors which could influence the present populations:

1. Introduction of Cutthroat Trout (*Salmo clarki*). These populations of endemic stickleback occur only where predatory fish are absent. Cutthroat Trout are the major fish predator on the stickleback and are widely distributed on the Queen Charlotte Islands. Dolly Varden, which are also widely distributed, forage on benthic invertebrates and do not normally feed on stickleback in this region. Artificial introduction of Cutthroat Trout into any of the three lakes would seriously reduce numbers or change the genome, since fish lacking defensive traits would be selectively eliminated from the population.

2. Winter kill. This is a potential problem for all fish populations during severe winters, especially

TABLE 2. Percentage of fish with missing spines and lateral plates

Lake	% of Fish Missing Spines and/or Lateral Plates					
	1st Dorsal	2nd Dorsal	3rd Dorsal	Pelvic	Anal	Lateral Plates
Boulton	0.03	80.0	2.3	65	6	0
Rouge	31.0	0.7	63.0	0	86	50
Serendipity	5.8	0	0	97	0	100

those in small lakes and ponds. Each of the three lakes had complete ice cover during the last three winters, and in Boulton Lake, where measurements were taken, ice thickness reached 45 cm and remained on the lake for nine weeks. That these small populations have not been winter killed for at least several thousand years may relate to the unusual limnological conditions to which the fish are exposed. One of the characteristics of Sphagnum is its capacity to bind cations. This results in highly acidic run-off, which among other factors, inhibits bacterial decomposers. Since oxygen depletion from bacterial activity is an important cause of winter kill, the naturally acidic conditions in these lakes may have contributed to winter survival of the fish. I have not yet found stickleback populations resident in any small ponds where pH values are near 7. European workers have shown that oxygen depletion in bog pools is significantly increased at higher pH values (Moore and Bellamy 1974). Domestic cattle or agricultural activity at Boulton or Rouge Lakes could result in higher pH. Lake fertilization programs, currently being conducted on the Queen Charlotte Islands by Federal Department of Fisheries and Oceans, could be expected to have a similar effect if any of these three lakes were artificially "enhanced".

Special Significance

These populations of stickleback are characterized by loss of morphological structures associated with predator defense (Table 2) and by tolerance to acidic waters.

Boulton Lake. The population contains a stable polymorphism of "non-spined" and "spined" phenotypes, the former occurring in littoral and the latter in limnetic regions of the lake (Reimchen 1980).

Rouge Lake. As well as loss of the third dorsal spine, anal spine and lateral plates in this population, there is a reduction in the number of dorsal and anal fin-rays, reduction in the size of the cleithrum and the pterygiophores and development of a postcranial hump. Fifteen per cent of the fish have two dorsal fins, resulting from an absence of the middle rays. In a review of the literature (Wootten 1976), no sticklebacks with comparable characteristics are described.

Serendipity Lake. The majority of fish lack all ves-

tiges of lateral plates and pelvic girdle. Dorsal spines, while present, are reduced to vestigial projections, and the cleithrum, supra-cleithrum and post-temporal bones are reduced in size. These fish closely resemble *G. aculeatus williamsoni*, found in California. Furthermore, the tolerance to acidic waters (pH 3.9) appears to be unparalleled for fish survival.

It is unknown whether these divergent populations and other endemic stickleback on the Queen Charlotte Islands have evolved from marine forms since the Wisconsin glaciation or whether these populations represent much older forms from a glacial refugium postulated for the region (Moodie 1984). No separate taxonomic status for these populations is currently planned; however, such a status may be warranted in the future when the full range of genetic variation in *Gasterosteus* becomes known.

Evaluation

At Boulton Lake, the habitat and the population size is stable. Rouge and Serendipity Lakes are going through a period of rapid habitat alteration due to the activities of the recently-introduced Beaver; because of the very small size of these two ponds, changes in pH, blockage of drainage, increased accumulation of organic debris and possible differences in predatory regimes may adversely influence the genetic structure and populations size. The stickleback populations in Boulton, Rouge and Serendipity Lakes can be designated rare with respect to the known variation in this species.

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