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Letters

Olfactory Cues in Migrating Salmon

1) Arthur D. Hasler's recent article, "Guideposts of migrating fishes" [*Science* 132, 785 (1960)] raises some fascinating questions. I agree with him, however, when he says he "may have overstressed the olfactory sense and its importance in migration," in discussing the cues utilized by migrating adult Pacific salmon on their trip upstream to spawning beds.

2) Reference is made in Hasler's article to a study by Wisby and Hasler in which these workers plugged the nasal sacs of migrating salmon and returned them to below a fork in the Issaquah River in Washington. When I first read the article I was struck by the fact that animals with plugged olfactory openings still "preferred" one branch over the other. The change brought about by the operation was not radical—did not reduce the choice to, say, the level of chance. It did not rule out the possibility of other controlling factors.

3) This result, I believe, is not the dramatic demonstration it should be if olfactory cues, in fact, are of primary importance in "guiding" salmon back to the "parent stream." The quotation marks in the foregoing sentence are there because the parent-stream theory is by no means as well demonstrated as Hasler leads one to believe. In addition, if one starts from this theory and accepts the implications, then one is forced to look for "cues" and stimuli which this animal can utilize in "identifying" its "own" stream and in differentiating it from other spawning streams in the Pacific Northwest. In short, the problem may be stated incorrectly.

4) H. B. Wood [*Publ. Am. Assoc. Advance. Sci. No. 8* (1939)] reports observations, for example, which led him to suspect that the temperature of the water at a fork in upstream migration governed the choice in Pacific salmon, and he points out that as the temperature differential reversed itself, salmon reversed their choice of stream. The fact that many fish are found in the parent stream could be the result of temporal relations of their life cycles which would bring them back to the area when the temperature of the parent stream favored a choice in that direction.

5) Further doubt is shed on the importance of olfactory cues in salmon migration by the lack of confirmation of conditionability of spawning adult salmon. Although the case for imprinting is not clear, the question of condition-

ing is difficult to support in view of the fact that Pacific salmon are generally believed to migrate (certainly by the time they have entered the fresh-water system) on empty stomachs. Furthermore, it is believed that they do not eat during migration and that the stomach itself is contracted. In the absence of evidence to the contrary it is hard to understand why salmon in this condition would respond to olfactory cues.

6) Intriguing as it is, the odor theory should be tested by direct observations on sexually mature and spawning salmon. The fact that salmon fingerlings can utilize olfactory cues does not mean that the migrating adult does, in fact, react to them.

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Concerning the points raised in Ramsay's letter I have the following comments (numbered to correspond with the numbering of paragraphs in his letter).

1) Odors have a distinctiveness which permits multifold differences. Because of the infinite combinations of plant communities and soil types in a river system, no two tributaries will have identical organic content; hence the seepage will have odors of never-to-be-duplicated distinctiveness. Recently J. P. Heath [*Ecology* 41, 381 (1960)] presented evidence that substances seeping through two stream bars induce salmon to congregate at the river mouth even though the sand bar blocks their entry.

2) The statistical analysis with the chi-square test does not support the criticism. Even though the Issaquah River carried 8 to 10 times as much water as the East Fork, the displaced and recaptured nose-plugged salmon returned at random ($p < 0.001$).

3, 4) Salmon in the Columbia River by-pass a stream in the coastal range to swim hundreds of miles upstream to enter and spawn in their home stream, which is identical in temperature to the one nearer the mouth [see B. T. Scheer, *Quart. Rev. Biol.* 14, 408 (1939)]. The temperature hypothesis has the same weakness as the carbon dioxide hypothesis cited in my article. The cues are not unique. While some homing salmon are known to stray, the issue here is to explain the precision of homing in the great majority.

5, 6) White salmon inherit the ability to return home, early conditioning or imprinting can alter their choice of place of return. Fingerlings transferred to a stream other than the home stream return there and not to the ancestral home stream. Some species of salmon

spend 1 to 3 years in fresh water before swimming to sea. It is the conditioning of the young and retention of this "memory" to adulthood that is important. That the adults do not feed in the later stages of stream migration is beside the point. Fish become conditioned to many scents other than food odors, notably to odors which induce alarm, schooling, and recognition of sex and to the body odor of their school mates [see A. D. Hasler, *J. Fisheries Research Board, Can.* **11**, 107 (1954)].

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Real Professionalism

There is grave danger to an already badly mangled academic freedom in one of the recommendations you cite as emanating from a report of an agency of the influential National Education Association [*Science* **132**, 439 (1960)]. I refer to the suggestion that college faculty members be required to hold state licenses.

Implementation would be greeted with loud cheers from state legislators from the rock-ribbed coast of New York's Feinberg Law to the sun-kissed shores of California's Levering Act. The most approving chorus would be the rebel yells of southern politicians.

An instructive example in point is found in South Carolina [*A.A.U.P. Bulletin* **46**, 87 (1960)]. There the governor succeeded in forcing two private colleges to dismiss professors he didn't like. This was achieved by having the State Board of Education refuse to allow any students of those colleges to qualify for licenses as public school teachers.

It is well known that teachers in the public schools and publicly supported colleges of the American South are afraid to take stands in favor of local compliance with Supreme Court desegregation decisions. Any state licensing of college teachers would intensify this fear at the college level and spread it systematically into the private colleges. It is not hard to anticipate the creation of the analog for college teachers of the literacy tests for southern voters which well-educated men and women fail consistently if they are colored.

Thus, the state licensing of college teachers would be, in the present atmosphere, an additional and effective weapon in the hands of the violators of academic freedom.

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