Journal of the Minnesota Academy of Science

Volume 12 | Number 1 Article 6

1944

Hybridization Between Northern Pike (Esox lucius) and Muskellunge (Esox masquinongy)

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The representatives of the six families above demonstrate similar results when they are considered individually, but what is more important, the conclusion attained receives mutual support from all the species when the results are considered collectively. On paleogeographic and paleoclimatic grounds, the path of migration into North America was via the Beringian Land Bridge.

NOTES ON THE ROOSTING OF THE STARLING*

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HYBRIDIZATION BETWEEN NORTHERN PIKE *(Esox lucius)* AND MUSKELLUNGE *(Esox masquinongy)*

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The muskellunge (*Esox masquinongy* Mitchill) is the rarest and most highly prized of Minnesota game fishes. This species and the northern pike (*Esox lucius* Linneaus) are the only species of the Pike Family, Esocidae, found in Minnesota. The many variations in the markings of the muskellunge have led many fishermen to believe that it hybridizes with the northern pike. Weed (1927) mentions the occurrence of possible hybrids.

For a number of years the Minnesota Department of Conservation has maintained a hatchery for the propagation of muskellunge at Nevis, Minnesota. Several hatchery men have reported that they have observed northern pike and muskellunge spawning together in the lakes near the hatchery. Mr. C. J. Falk, former superintendent, informed the writer that prior to 1938, he had successfully fertilized muskellunge eggs with northern pike sperm when he secured a ripe female muskellunge but could find no suitable male.

In 1939, the writer, in cooperation with the Minnesota Department of Conservation, undertook a study of the cross breeding of muskellunge with northern pike at the Nevis hatchery. The breeding stock utilized by this hatchery were local wild muskellunge, northern pike, and a silver pike then called silver muskellunge but since recognized as a variety of the northern pike (Eddy and Surber, 1943). Artificial propagation of these fishes was a relatively simple matter as the eggs are fertilized after they are laid. The ripe males and females were relieved of their milt (sperm) and

* Published in the Flicker *16:* No. 3, 47–50 (October) 1944.

eggs by stripping or gently manipulating their distended sides. The eggs were fertilized by mixing them in a container with the sperm of the desired species and were then placed on trays in running water or in jars for hatching. During the springs of 1939, 1940, and 1941 all possible crosses were made between these three kinds of fishes and the resulting offspring were placed in aquaria at the University and in the Isaac Walton League rearing ponds south of Minneapolis. As many as possible were raised to ages from one to four years.

Muskellunge, northern pike, and the silver variant were also produced at the hatchery or were secured from wild stock for the determination of the characters for each species involved. Due to heavy mortality resulting from difficulties of rearing only a limited number were reared to a sufficient size for study. Two hundred northern pike, forty-eight silver pike, thirty-nine muskellunge, and one hundred and ninety-nine muskellunge-northern pike hybrids were secured for a detailed study of their morphological characters.

No significant differences in body form could be found between the three kinds and their hybrids as the body depth and length ratios all showed wide individual variations for each kind. No important differences could be found in the head measurements. The scalation of the cheek in general showed some differences but was not reliable as this was somewhat variable in the muskellunge. Definite specific characters were noted in the number of pores on the underside of the lower jaw, the number of scales in the lateral line, and the number of branchiostegal rays. Although the ranges overlapped, the number of rays in the dorsal and anal fins showed specific differences.

The northern pike is widely distributed over Minnesota occurring in practically all waters suitable for fishes. It has a wide range extending over much of North America, north of the Ohio River, and over northern Europe and Asia. The body markings are somewhat variable but in the adult tend to follow a pattern of light spots on a dark background. Juveniles of the northern pike are not spotted but are streaked with light cross bars which may be retained until they are four months to one year old. The dorsal, caudal, and anal fins are usually marked with three or four rows of large irregular spots.

All northern pike examined had the cheek entirely scaled. Ninety-three per cent had ten pores on the underside of the lower jaw; four per cent had nine pores; and three per cent had eight pores. None had more than ten pores. The branchiostegals numbered from 12 to 16 but mostly ranged from 14 to 15. Their lateral line scales numbered from 117 to 132. Most of them ranged from 120 to 129. Their dorsal fin rays numbered from 17 to 19. Their anal fin rays numbered from 14 to 18. Most of them ranged from 14 to 15.

The silver pike was first noticed by the local residents in Lake

Belletaine at Nevis about 1930. They were, at first, thought to be muskellunge and for several years were propagated in the hatchery as such. All were found to breed true to the parent types. A number were reared at the University to ages of three and four years. They differed from the northern pike only in their markings, lacking all the spots characteristic of the northern pike. Their bodies had a uniform silvery coloring and each scale was flecked with gold. This flecked condition occurs in typical northern pike but is obscured by the markings. The dorsal, caudal, and anal fins of the silver pike were speckled with numerous fine spots. All of their other characters were found to be the same as for the northern pike. Their cheeks were entirely scaled. They never possessed more than ten pores on the underside of the lower jaw. They had from 12 to 15 branchiostegal rays as in the northern pike but did not show as great a range. They had from 18 to 19 dorsal fin rays and from 15 to 16 anal fin rays, all of which were in the range for northern pike rather than for that of the muskellunge.

The muskellunge is found in few numbers in several widely separated areas in Minnesota. A thinly scattered population occurs in the Mississippi River from below Lake Pepin up to at least Little Falls. They occur in a number of lakes in the vicinity of Walker, Nevis, Cass Lake, and Grand Rapids. They are also found in Lake of the Woods and tributary waters. Nowhere in Minnesota are they very abundant except, possibly, in Shoepac Lake, a small lake lying in the wilderness area between Rainey Lake and Lake Kabetogama where, as far as the writer could determine, they were quite abundant and were not associated with northern pike.

The range of the muskellunge is confined to three areas in North America: the Great Lakes and St. Lawrence drainages, the upper Ohio Valley, and the Mississippi drainage of Minnesota and Wisconsin, and the arctic drainage of Minnesota and adjacent Canada. The muskellunge in each of these areas is considered as a separate subspecies.

Muskellunge have their bodies marked with dark and rather wavy bars which may break up into spots which may become quite faded. The dorsal, caudal, and anal fins are more or less spotted. The spots are usually smaller than those of the northern pike and sometimes are barely discernible. Individuals of the local subspecies *immaculatus* have their bodies marked with bars or spots or a combination of the two.

The muskellunge has been usually distinguished from the northern pike by the scalation of the cheek which is supposed to be scaled on the upper half only. The muskellunge studied, and others previously observed, show that this is not a reliable character as twenty-two per cent of the specimens used in this study were found to have the lower half of the cheek more or less scaled. It

is possible that this could be the result of some previous natural crossing with northern pike as all the specimens from Shoepac Lake, which was apparently free from northern pike, showed scales on the upper half of the cheek only. The total number of pores on the underside of the jaw always exceeded ten and in a few ranged as high as eighteen. The number of these pores seems to be a good character for separating muskellunge from northern pike (Hubbs and Lagler, 1941; Eddy and Surber, 1943). The branchiostegal rays numbered from 16 to 19, which was more than those usually found in the northern pike. The scales of the lateral line ranged from 130 to 157 but most of the counts ranged from 145 to 154, which was much higher than in northern pike. The dorsal fin rays numbered 19 to 21. The anal fin rays numbered 17 to 20. Most of the counts ranged higher than the average for those of the northern pike.

Muskellunge eggs were fertilized with northern pike sperm and northern pike eggs were fertilized with muskellunge sperm. The two sets of resulting hybrids showed no morphological differences. Many were reared to four months and some to over three years of age. The hybrids were always strongly barred and never showed any sign of the spotted markings of the adult northern pike. The bars were darker and more distinct than those of the average muskellunge and lacked the tendency to break up into spots. The dorsal, caudal, and anal fins were spotted. Ninety-one per cent had their cheeks entirely scaled and only nine per cent showed the lower half of the cheek to be wholly or partly without scales. The number of scales in the lateral line ranged from 132 to 139 and were intermediate between the ranges for both parents as seen in the following table.

Lateral Line					
Esox lucius	47	146	7		
Scales	117–122	123–129	130–141	142–150	150–155
Esox masquinongy			4	11	24
Hybrids		32	167		

The branchiostegal rays of the hybrids numbered from 17 to 18 as in the muskellunge. The following table shows the individual distribution of the branchiostegal rays.

Branchiostegal Rays	12	13	14	15	16	17	18	19
Esox lucius	6	10	107	64	13			
Esox masquinongy					5	11	19	4
Hybrids						48	151	

Seventy-five per cent of the hybrids had 10 pores on the underside of the lower jaw as in the northern pike. Twenty-one per cent had 11 pores and four per cent had 12 pores as found in some

muskellunge but no hybrids had more than twelve. The hybrids had from 18 to 20 dorsal fin rays. Most of them had from 19 to 20 which was rather intermediate and overlapped the ranges of both parents as may be seen from the following table.

Dorsal Rays	17	18	19	20	21
Esox lucius	29	131	40		
Esox masquinongy			17	14	8
Hybrids		49	118	32	

The anal fin rays of the hybrids numbered from 16 to 19, overlapping the ranges for both parents as may be seen in the following table.

Anal Fin Rays	14	15	16	17	18	19	20
Esox lucius	67	110	14	7	2		
Esox masquinongy				3	18	13	5
Hybrids			16	132	36	15	

Crosses were made between silver pike and muskellunge and the resulting hybrids were identical in every respect with those resulting from the muskellunge and typical northern pike cross. The silver pike were crossed with the typical northern pike in 1939 and in 1940. Both years the resulting fry suffered great losses and only a total of thirteen survived to an age of over one year. They differed greatly from either parent in their markings. They were peculiarly mottled with dark splotches which resembled the splotches of a black crappie *(Pomoxis nigro-maculatus)*. The dorsal, anal, and caudal fins were finely speckled. The other characters were identical with those of both parents.

The fry and fingerlings of the muskellunge-northern pike cross seem to be hardier than those of the muskellunge. In some years, but not always, they grew faster than young muskellunge. Hubbs and Hubbs (1933) found that the hybrids of sunfishes grew faster than either of the parent species but seemed to be infertile. Attempts were made to determine the fertility of the hybrids but no results were obtained. Several of the hybrids were retained in a rearing pond and in their fourth year, the females became distended with eggs but could not be persuaded to ripen and release them. Perhaps the use of pituitary extract would have solved this problem but war conditions made it necessary to drop the attempt.

Muskellunge eggs seem to be very delicate and the hatch was often low. In 1941, the hatch for muskellunge eggs ranged from one to eight per cent. The hybrid eggs showed greater vitality and from 22 to 45 per cent hatched. This was only for one year and varied in previous years, although the muskellunge eggs usually showed a lower hatch. The muskellunge eggs are slightly larger than those of the northern pike and hatched in about 14 days; whereas

the northern pike and silver pike eggs hatched in 10 to 12 days. The cross fertilized eggs usually hatched in 11 to 12 days.

These studies indicate that it is easy to produce hybrids between muskellunge and northern pike. They also indicate that it is possible for such crosses to occur in nature. So far as can be determined, the hybrids seem to be desirable game fishes resembling the muskellunge in general appearances although many of the detailed characters tend to be intermediate between the two parent species.

The writer wishes to thank Dr. Kenneth Carlander and Mr. John Appleget who helped with this study. He also wishes to acknowledge the cooperation of the Minnesota Department of Conservation and the Minneapolis Chapter of the Isaac Walton League and the help contributed by the many employees of the Nevis Hatchery.

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THE EFFECT OF CLINOSTOMUM ON THE SIZE OF THE YELLOW PERCH

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ABSTRACT

An attempt was made to determine the effect of larval flatworm parasites, *Clinostomum marginatum,* on the size of the yellow perch, *Perca flavescens,* under natural conditions. Twenty-eight hundred fish ranging in age from 1 to 7 years were examined internally and externally for metacercariae. The parasites were counted, the length and weight of the fish recorded, and the age determined by scale examination. The size index (product of weight and length) was correlated with the number of parasites in three age groups; namely, one, two, and three year olds. The older fish were not used in the computations due to their small numbers. The correlations were 0.338, 0.336, and 0.667 for the one, two, and three year olds respectively. Within the limits of these observations the results indicate