Predators follow prey – in evolving, as well as hunting

After alewife migration had been blocked by the damming of rivers in the North-eastern US, not only did new types of alewife emerge in coastal lakes but a distinct form of pickerel evolved which is specialized for alewife predation. The findings of recent research on this predator show how eco-evolutionary interactions are affected by human interventions in the environment. And they also shed light on the diversification of fish species in Swiss lakes. *By Sibylle Hunziker*

Jakob Brodersen

Fig. 1: To study morphological and genetic differences in chain pickerel, samples were collected from 12 US lakes. Electrofishing (pictured here) was carried out after sunset in the littoral zone.

Pickerel inhabit shallow, near-shore (littoral) waters, lurking in the reeds as they wait for prey. This is the standard textbook account, and it has not previously been called into question by scientists. But in an article published in the latest issue of *Nature Communications,* researchers from Eawag and Yale University describe chain pickerel *(Esox niger),* which have become open-water (pelagic) specialists, developing a new body shape as they evolved. Within a period of less than 300 years, this fish species has thus adapted to changes in the life history and size of the prey available in the lakes where it resides.

Human-driven evolution

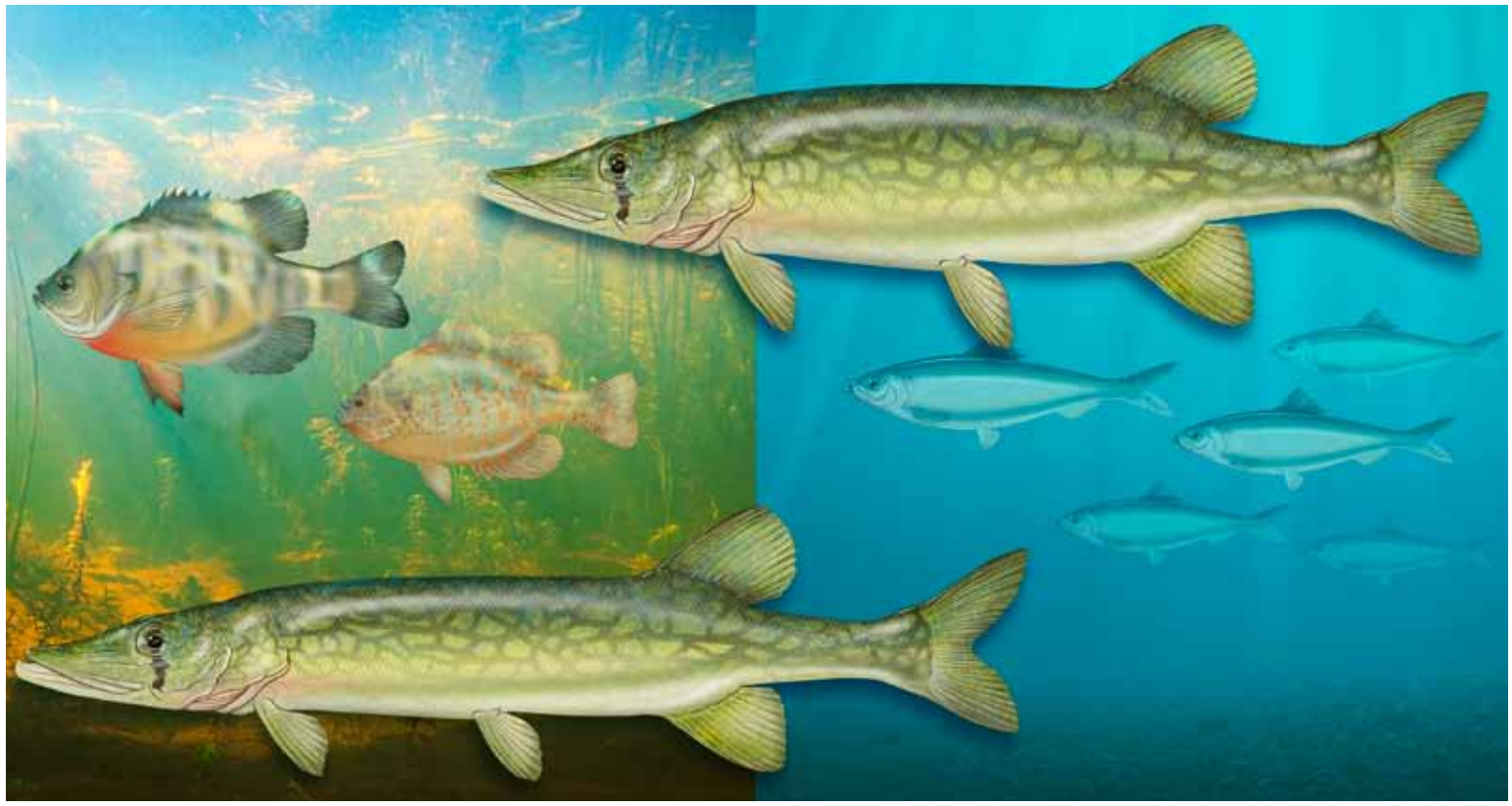
During the colonization of the East coast of the US around 300 years ago, numerous rivers and streams were dammed to power the settlers' mills. As a result, migration of the alewife *(Alosa pseudoharengus),* – which had previously swum upstream from the sea to spawn in freshwater lakes – was blocked at many sites. In some of the "landlocked" lakes, the alewife is no longer found today. Others, however, now harbour descendants of the fish that were cut off from the sea. Since they first began to remain in the lake all year round, they have adapted to the new environmental conditions: unlike migratory alewife, they now reside in the open waters and have become specialists, feeding on zooplankton; they have thus also become smaller.

Alewife in landlocked lakes also differ genetically, as demonstrated some years ago by David Post of Yale University. Building on this research, Jakob Brodersen of Eawag has now studied the largest predator found in these lakes – the chain pickerel (Fig. 1). It has long been known that environmental changes trigger adaptive and evolutionary processes, and that the development of new species and forms in turn affects environmental conditions – for example, altering habitat use and the availability of food resources. However, predators at the top of the food web have not previously been studied. As Brodersen points out, "In order to understand what happens at that level, you need to look at the entire ecosystem."

New prey, new body shape

Systematic surveys in a total of 12 lakes revealed that chain pickerel occur in littoral zones regardless of whether a lake contains alewife or not, and whether alewife populations are isolated or can still migrate to and from the sea. "But," says Brodersen, "it was only in landlocked lakes that pickerel populations were also found in the open waters." Analysis of their stomach content indicated that the pelagic pickerel mainly feed on alewife. They thus differ from the littoral pickerel, whose main prey is the sunfish. But because alewife have a higher lipid content than sunfish, their predators can also accumulate greater fat reserves. Brodersen notes: "That's a survival and reproductive advantage which presumably made this new mode of life particularly attractive for the chain pickerel."

Also adapted to its new habits and habitat is the pelagic pickerel's body shape: its muscular, streamlined form is ideal for foraging on shoals, while the arrow-shaped littoral pickerel is adapted to lurking in reeds and making rapid strikes (Fig. 2).
Nonetheless, genetic analysis showed that the pelagic pickerel have no closer relatives than the littoral pickerel in the same lake. Brodersen explains: "This means that the fish preying on alewife have not immigrated from somewhere else but have developed out of and alongside the pickerel living near the shore of the same lake."



Patrick Lynch, Yale University

Fig. 2: Chain pickerel inhabiting near-shore (littoral) areas have an arrow-like body shape and feed on sunfish (left). Those found in open-water (pelagic) habitats are more muscular and streamlined; they feed mainly on alewife (right).

Divergent forms also found in Switzerland

These findings show that, rather than simply modifying the environment, human interventions alter the complex interactions between ecology and evolution which occur at various levels of the food web, extending all the way up to the top predator. The next question Brodersen plans to address is how the emergence of new forms of pike and similar predators affects freshwater biodiversity – although this research is focusing on fish in Swiss lakes and rivers.

In Lake Lucerne, for example, Brodersen has also found littoral and pelagic pike which resemble those occurring in the US. Talking to local fishermen, he noticed that they distinguished, as a matter of course, between near-shore and open-water pike. While the former feed on species such as perch and roach, the latter have a smaller head and prey on the endemic "Albeli" *(Coregonus zugensis).* According to Brodersen, "For generations, fishermen have also observed similar differences in other species, such as trout, which utilize streams or rivers in quite different ways." For this reason, he and his students frequently first consult professional fishermen before attempting to identify the causes and evolutionary mechanisms which have given rise to this diversification.

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