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Foraging mode ecology of stream-dwelling salmonids in Iceland

Here I provide a status report for the project "Foraging mode ecology of stream-dwelling salmonids in Iceland". I present this information in three sections. I begin with a brief introduction of the theory and predictions for this research. Next I highlight a few details of the progress made since the spring of 2005. Last I provide an idea of the expected project contribution in terms of published scientific papers.

Introduction:

General theory

Often animals express fine-scale foraging behaviours that reflect important elements of their ecology. Of these behaviours, foraging modes specifically demonstrate how animals search for, attack and consume their prey. These modes are not necessarily discrete, yet animals may typically forage in two ways termed "sit-and-wait" and "widely-foraging". "Sit-and-wait" foragers remain still while they scan their surroundings, then attack as prey enter striking distance. Alternatively, "widely foraging" animals travel more expansively seeking out food while on the move (Huey and Pianka 1981; see McLaughlin 1989; Helfman 1990; Hart 1997; Perry and Pianka 1997). Because foraging modes reflect how the local environment is used by individuals, these modes may ultimately link fine-scale individual foraging actions to habitat use patterns and broad-scale organizational (population, community) phenomena observed in the wild.

Aim/Predictions

My aim is to establish the foraging mode patterns of Arctic charr, brown trout and Atlantic salmon across a gradient in food availability and physical habitat structure in Iceland's freshwater stream environments. In order to increase our understanding of mode variation among different habitats in streams I will test two general foraging mode predictions with respect to how food and physical habitat may influence salmonid foraging. (1) Productivity level should be a strong predictor of mobility, in areas of high drift salmonids should tend to "sit-and-wait" while foraging, conversely where drift abundance is lower salmonids should forage more "widely". (2) Under similar production

levels current velocity strongly influences prey availability: thus in higher current velocities salmonids should favour a sedentary approach and ambush drifting prey, whereas in lesser currents a more mobile approach is expected along with a reduced proportion of drift feeding. Also, because these species are expected to vary in their habitat use I expect them to differ in their forage mode.

Progress:

Field/Lab work and Methods

In 2005, observations of young-of-the-year (YOY) salmonids were made on 58 Arctic charr, 30 brown trout and two Atlantic salmon. Several additional sites with brown trout and Atlantic salmon present were also identified. Little information exists for these salmonid rivers in Iceland and consequently I spent consider amounts of time searching for locations to observe fish. These searches were not without merit, many identified locations where salmonids were foraging, which should make data collection easier in 2006.

During this initial summer I chose to focus primarily on streams containing Arctic charr and secondarily on brown trout and Atlantic salmon. This decision was made for two reasons. First the summer of 2005 was unusually cold and wet (according to colleagues). It was my general observation that Arctic charr were regularly active at lower temperatures than the other two species. Therefore I was more likely to observe active charr on any given day than brown trout or salmon. The latter two species were often very cryptic and remained inactive hiding in the substrate under cold conditions. Second, the focus on Arctic charr before salmon or brown trout made sense because no prior studies have described Arctic charr behaviour while salmon and brown trout behaviour has been described in other areas. Despite this focus on charr, I did manage to collect considerable information on brown trout behaviour as well.

To complete the species comparison I plan to observe 180 individuals, 60 for each species, finishing the observation in the summer of 2006. The observations for each species will be divided over 4 rivers. This differs from the original proposal of 30-40 individuals from each species. The increase in observations will allow me to have a wider range of habitat variability with enough individuals to display a significant trend.

Behavioural observations

In 2005, behaviours were recorded for 58 Arctic char, 15 from each of 4 streams (Brunastadura, Grafara, Nordura, Myllua),and 30 brown trout from 2 streams (Huseyjarkvisl, Thvera) and 2 Atlantic salmon from 2 streams (Saemundara, Fljota). Attempts were made to observe fish across the range of habitats available in each stream. If these species are variable in their foraging habits, then sampling a range of habitat types should provide opportunity to observe individual differences in behaviour.

Data were collected between June and September 2005. Almost 24hrs of daylight in the summer allowed me to make behaviour observations between 09:00 and 20:00.

All observations were made by a single observer using one of two techniques depending on the stream conditions (mostly stream depth and current velocity). These techniques were: (1) snorkeling where the observer lay motionless downstream from the focal fish and recorded observations on plastic paper. Or (2) watching from the stream bank from behind a blind. These stream bank observations were recorded on a digital voice recorder or a video camera.

Behaviour was measured similar to (McLaughlin 1992; McLaughlin 1994; Biro 1995) with some notable variations. Focal fish were observed for approximately 20 min with no less than 10 min of observation. Also, behaviours were recorded for 5 sec intervals but alternated every other interval as in (Biro 1995). Some additional variables were measured, including whether a pursuit for food was initiated from a sedentary or mobile state.

Environmental variables

Following each behavioural observation, stream drift was collected and several environmental measurements were recorded. Drift was sampled by the placement of a drift net (25x30 cm; 250μm mesh) centered on the fish location. The current velocity was taken at three positions at the opening of the drift net for calculation of the drift rate. Drift nets were submerged for 20 minutes in the more productive locations and 30 minutes in areas with less drift. All samples were stored in 70% ethanol. In the laboratory large samples were subsampled, otherwise all YOY prey sized items were counted.

The average current velocity and the current velocity at the depth where the individual fish was foraging (nose velocity) were recorded. Water temperature, time of day, ambient

light conditions, depth and substrate were also noted to describe the habitat conditions for each fish.

Preliminary Results (Arctic charr)

This study suggests that Arctic charr (0+) are mainly drift feeders in streams. For the 58 individuals observed in 2005, approx. 90% of all foraging forays were directed toward drift, while fish made contact with the stream bottom in only 10% of foraging forays. Of drift forages, most are directed within the water column and attempts at food on the surface are rare. Specialized behaviour like this for Arctic charr in lakes is often suggested to occur because of the advantages of focusing on a beneficial, usually abundant, distinct resource type. In streams, the young Arctic charr focus on the drift which provides a somewhat continuous form of mobile food.

My next step in the analysis is to determine if foraging foray location (substrate, water column, surface) varies with environmental factors (eg. amount of drifting food). Because many individuals observed in this study exhibit a proportion of different foraging modes (benthic vs. drift), I intend to use a logistic regression to determine the likelihood that an individual will adopt a particular mode in relation to its environment. This will determine for instance if salmonids vary in there propensity to eat more often from the bottom if the amount of mobile food is reduced.

While preliminary results strongly suggest arctic charr prefer to feed from the water column, individual mobility tends to be variable. Individuals ranged from taking an almost entirely sit-and-wait ambush approach (proportion search time moving 0) to being rather mobile (proportion of search time moving 84%). On average searching charr were mobile for 24% of the observation time suggesting a tendency to sit-and-wait in streams. The general trend suggests that the proportion of search time spent moving decreases with an increase in drift rate. It will be interesting to see how the three species compare in this respect. Based on some ideas about habitat preference, it may be expected that charr and brown trout may show a greater tendency to be mobile when there is less drift than Atlantic salmon. The opposite relationship holds for foraging rate which increased with the amount of available drifting prey.

Multivariate models will also be tested to determine if biologically explainable combinations of variables better explain the foraging actions of these salmonids. These

models will reflect variables that are expected to affect salmonid behaviour and will thus be based on "*a priori*" predictions.

Future

In the second field season (summer 2006), I will gather data for Atlantic salmon and finish the collection for brown trout. I expect to write and defend a thesis by the end of December 2006.

Contribution:

The goal of this research is to produce two published manuscripts. The first applies foraging mode theory to describe the behaviour of YOY riverine Arctic charr. Despite a sizable literature for Arctic charr, this is the first study to examine the behaviour of individuals in streams. My aim is to submit a manuscript for publication during the winter of 2006. The second will compare the foraging modes exhibited by the three salmonid species (Atlantic salmon, brown trout, Arctic charr) found in Iceland rivers. Use of similar data collection methods will provide a rare comparison of the foraging behaviour for these salmonids. My aim is to send a manuscript for publication in the spring 2007. Expected date of completion for the entire project is unknown at this time.

References

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