Migration patterns and spawning habitat of ide (*Leuciscus idus*) in three streams on Gotland

Migrationsmönster och lekmiljöer för id (*Leuciscus idus*) i tre vattendrag på Gotland.

Ellen Lindström

Master thesis project· 30 hp
Swedish University of Agricultural Sciences, SLU
Faculty of Natural Resources and Agricultural Sciences
Department of Aquatic Resources (SLU Aqua)
Uppsala, 2026

Migration patterns and spawning habitat of ide (*Leuciscus idus*) in three streams on Gotland.

Migrationsmönster och lekmiljöer för id (*Leuciscus idus*) i tre vattendrag på Gotland.

Publisher:	Swedish University of Agricultural Sciences, Faculty/ Department/Collaborative Centre
Supervisor:	Daniel Nyqvist, Swedish University of Agricultural Sciences, Department of Aquatic Resources
Assistant Supervisor:	Joacim Näslund, Swedish University of Agricultural Sciences, Department of Aquatic Resources
Examiner	Josefin Sundin, Swedish University of Agricultural Sciences, Department of Aquatic Resources
Credits:	30 hp
Year of publication:	2026
Place of publication:	Uppsala
Cover picture:	Ide in Närkån 1 April 2026, photo taken by Ellen Lindström

Abstract

The purpose of this study was to investigate migration patterns and spawning habitat of ide (Leuciscus idus) in three streams on Gotland (Idån, Närkån & Snoderån). Visual surveys were conducted from land along fixed routes every 2–7 days from March 11 (Idån and Snoderån) and March 24 (Närkån) to April 27. Spawning was first observed April 1 and that the number of observed fish correlated with spawning. The temperature varied between 6.6 – 9.1 ˚C in the different streams when spawning occurred, and the spawning grounds with highest egg density were at shallower depths (0,5 m/s), at higher water velocity (>0,5 m/s) and with stone, gravel and blocks as the dominated substrate. One week after spawning was first observed, potential spawning sites were surveyed for eggs, with egg density (categories 1–7), water depth, water velocity and substrate type recorded. A fry trap in Idån was deployed two weeks after spawning was first observed. Downstream-drifting fry were caught 5 weeks after spawning, with 260 individuals caught over a three-week period. Fry ranged in body length from 5 to 16 mm, suggesting variation in hatching time and growth rate among individuals. Results also indicated that ide showed a preference for areas with overhead cover such as bridges and trees, and that fish numbers increased further upstream during peak spawning. Future research using telemetry could provide insights into individual migration routes before and after spawning and whether ide exhibit homing behaviour.

Keywords: Baltic sea, drifting, visual observation, upstream migration, downstream migration, fry, fry trap,

Table of contents

List of tables

List of figures

Abbreviations

SLU	Swedish University of Agricultural Sciences
Bp	Turbulent steep streams with stones and boulders, with plane bed stream
Bt	Turbulent steep streams with stones and boulders, with step pool stream
Bx	Turbulent steep streams with stones and boulders
Cv	Riffle-pool stream, with riffle-pool stream
Cx	Riffle-pool stream
Ex	Meandering alluvial streams
Fö	Incised alluvial streams
Zz	Highly modified watercourses

1. Introduction

Migrations and large–scale movements of fishes have been noticed through history. The definition of migration is a directed movements that result in a shift between two or several separate habitats, occurs with regular periodicity during the lifetime, and is exhibited by most of the population at sometime during their lifecycle (Lucas & Baras, 2001). This movement can be seen as a strategy involving the whole or a part of a population to move in time through different places (Lucas & Baras, 2001). Fish migration has been associated with three main purposes: spawning, feeding and refuge (Heape 1931; Northcote 1978). A refuge can be used to escape predation or drought, or to avoid other unfavourable environmental conditions (Lucas & Baras, 2001). Even though many species migrate primarily for reproduction, energy balance and food availability may constrain migration timing and subsequent survival (Brönmark et al., 2008). Migration can occur between salt and freshwater (diadromous) within freshwater (potamodromous) and within saltwater (oceanodromous) (Thurow et al., 2012). Within the diadromous spawning migration there are three categories, anadromy, catadromy and amphidromy (Morais & Daverat, 2016). Anadromous fishes grow in saltwater and spawn in freshwater, and the opposite occurs for catadromous fishes. Amphidromy means that spawning occurs in freshwater, the fry grows in saltwater, and the juveniles subsequently migrate back to freshwater where they live until spawning (Morais & Daverat, 2016).

In anadromous species, upstream migration in rivers and streams can be beneficial for the egg development and fry growth since water heats up more quickly and there are more suitable habitats for spawning and rearing (Lucas & Baras, 2001). Juveniles in rivers and streams are often exposed to lower predation pressure than those in marine environments (Brönmark et al., 2008). Flow condition is often a trigger for upstream migration (Northcote 1984; Hawkins & Smith 1986; Jonsson 1991) and for some species temperature and day length also effects the timing of the upstream migration (Lucas & Baras, 2001).

One group of fishes that include migrating species is the family Leuciscidae, of the order Cypriniformes. Examples of fishes in the Leuciscidae family are ide (*Leuciscus idus*), roach (*Rutilus rutilus*), common bream (*Abramis brama*) and asp (*Leuciscus aspius*) (Schönhuth et al., 2018). Ide, the subject species of this study, is a relatively wide–spread and common species where we have a general knowledge gap in Sweden (Havs– och vattenmyndigheten, 2023). Therefore, as for many freshwater fish, it is difficult to identify how threatened the ide is with certainty. Ide is a potentially important species within environmental assessments, since it is widely distributed and does not readily leap over migration barriers, unlike salmonids, and can therefore serve as an umbrella species for migrating fishes that are relatively weak swimmers (Havs– och vattenmyndigheten, 2023).

1.1 Ide

Ide lives in fresh– and brackish water and occurs in most of the catchment areas connected to the Baltic Sea, including the Bothnian Bay. It is absent in Scandinavia north of 69 °N (FishBase, 2026). To the southwest, the natural distribution boundary is in western France, and to the east it is defined by the catchment areas of the Lena and Aral rivers (FishBase, 2026). Ide has been introduced to Great Britain, Italy and several other European countries and to USA (FishBase, 2026). In Sweden, adult ide occurs in streams along the coast, large slow–flowing rivers, in lakes, and in the Baltic Sea. Ide can handle salt concentrations up to ca. 15 permille (Havs– och vattenmyndigheten, 2023). Juveniles occur in shallower areas of the same habitats, often in association with dense vegetation (Havs– och vattenmyndigheten, 2023). Beyond studies from Cala during the period 1965–1970 (Cala 1970a, b; 1971a, b, c; 1975) there are few published scientific ide–related studies from Sweden (Havs– och vattenmyndigheten, 2023).

Ide has reddish fins while the rest of the body shift between silver, brass and grey while it is whiter on the abdomen (SLU Artdatabanken, 2026). Ide is a generally shoaling fish with an omnivorous diet usually consisting of insects, vegetation and crustaceans. It grows to around 30–55 cm and the growth rate is rapid until they are sexually mature, after which growth declines. The growth rate is the same for both sexes (Rohtla et al., 2021). The generally stated life span is between 10–15 years (Havs– och vattenmyndigheten, 2023) but in Estonia they found a 29–year–old ide by otolith analysis (Rothla et al., 2015). An ontogenetic shift in diet happens for the fry reaching 20 mm. Fry below 20 mm generally eat zooplankton while individuals over 20 mm tend to eat insects. Snails, worms, various plant materials and the water louse (*Asellus aquaticus*) dominate the diet for ide over 140 mm. Individuals over 260 mm generally eat plant materials and small fish (Havs– och vattenmyndigheten, 2023). When turbidity is high the primarily visually oriented ide experiences a reduction in foraging efficiency (Kulíšková et al., 2009).

For juvenile ide the predation threat consists of piscivorous fish such as pikeperch (*Sander lucioperca*), northern pike (*Esox lucius*) and brown trout (*Salmo trutta*). Other predators at the older life stages are piscivorous birds such as cormorants (*Phalacrocorax carbo sinensis*), osprey (*Pandion haliaetus*) (Rohtla et al., 2021). Eggs and larvae can be heavily predated by smaller fish species such as the three–spined stickleback (*Gasterosteus aculeatus*) (Rohtla et al., 2021).

Anthropogenic environmental threats are migration barriers, pollution, eutrophication, habitat modifications in brackish waters, non–native species introductions, water retention structures and habitat destruction in rivers and overfishing (reviewed by Rohtla et al. 2021). In rivers, human activity such as dredging, excavation or damming of river sections are listed as having had a negative effect on ide (Havs– och vattenmyndigheten, 2023). Ide is sensitive to low dissolved oxygen concentrations in the water, as often seen in eutrophic or turbid rivers and lakes (Rohtla et al., 2021). Little economic value (Bonow & Svanberg 2013) and low interest among anglers has led to few ecological rehabilitation measures being directed towards the ide (Havs– och vattenmyndigheten, 2023).

1.1.1 Life–history

Ide is iteroparous which means that they spawn several times after reaching maturity (SLU Artdatabanken, 2026; Rideout et al., 2005). Sexual maturity occurs at around 10 years age for ide in Lerviksbäcken, Kalmar, one of few investigated Swedish populations (Havs– och vattenmyndigheten, 2023).

In the Baltic Sea the development of ide is adapted to the brackish water of the sea. The dominating Baltic life–history strategy includes anadromous migration. Some populations, however, live in freshwater their whole lives (Havs– och vattenmyndigheten, 2023) and some can spawn in brackish water (Rohtla et al., 2015).

Ide spawn in spring; some ide migrate upstream into rivers and streams in autumn but in smaller streams it is more typical that they migrate during early spring (Cala, 1970b). Advantages with early migration include extended time for growth before more individuals arrive and the competition increases for food and space (Rohtla et al., 2015). Spawning has been described to occur in shallow areas with stone and gravel sediment and elements of vegetation, in flowing freshwaters (Cala, 1975). Or, as described from Estonia, the spawning happens on algae or sandy/stony bottoms (Rohtla et al., 2021). The egg stick to vegetation, stones and other substrate and areas with many eggs can look like they are covered by sand (Havs– och vattenmyndigheten, 2023). The male ide develops clearly distinguished warts on the head (breeding tubercles) during the spawning period (Havs– och vattenmyndigheten, 2023) and Müller & Berg (1982) shows that ide display natal homing behaviour.

According to a review by Rothla et al. (2021), spawning starts soon after ice break–up and lasts for 3–9 days, given that the temperature is stable. However, this information does not appear to be in line with the current patterns seen in Swedish rivers from fish counter registrations typically in April (Fiskdata.se, 2026). The spawning is described to be triggered by water temperatures (Rohtla et al., 2021). Males are assumed to be the first ones reaching the spawning grounds and the last ones leaving (Rohtla et al 2021). In Sweden the spawning occurs between March and the beginning of June at water temperature between 4–13 °C (Rohtla et al., 2021). The intensity of ide migration (in terms of number of fish) has been associated with flow, water temperature and day length (Waernulf, 2025).

The development of the eggs depends on the water temperature but usually lasts for two weeks at 10–12 ˚C. The median length for newly hatched ide fry is around 6–7 mm (Cala, 1970b) and after absorbing the yolk sac at around six mm they start to actively swim (Järvalt et al., 2003). Early larval stages typically partake in downstream drift (Rohtla et al., 2021). The first year the ide larvae gain rapidly in size; when they are two months old, they are usually 16–24 mm long, and they reach 45–57 mm after six months (Rohtla et al., 2021). The velocity at the riverine nursery habitat used during the early larval stage before downstream migration to the sea has been described as 0–10 cm s–1 at depths of 0–100 cm (Vriese et al. 1994; Rohtla et al., 2021). In the Baltic, the young of the year migrate to sea during the first two months (Rohtla et al. 2015; Rohtla 2021) or stay in freshwater for a year and then migrate to the sea (Cala, 1970; Rohtla 2021). Around the Baltic sub–bay Väinameri (Estonia), for example, young of the year emigrate from natal sites to the sea before summer and 95% emigrated within the first month post–hatch (Rohtla et al., 2015).

1.1.2 Gotland

Ide occurs in many streams on the Baltic Sea island of Gotland, including Idån, Närkån, Snoderån, Bangån, Varbosån, Hultungsån, Dalhemsån, Anerån, Marpeträsk and Gothemsån (Fig. 1; Elida Lundgren, personal communication). The average catch in Sweden between 1914 and 1963 was approximately 120 tonnes per year with the largest catches made in Stockholm County, southern Kalmar County, and on Gotland, where some small–scale commercial fishing still exists (Bonow & Svanberg 2013). Demand for ide burgers (burgers made from ide meat) appears to be non–trivial, and their commercial availability at a profit has contributed to increased interest in ide (Bonow & Svanberg 2013). However, there is no management plan for the species. Previously important areas such as Lausmyren have been drained for agricultural purposes (Bonow & Svanberg 2013). In line with the general Swedish situation, there is a knowledge gap regarding ide on Gotland (Havs– och vattenmyndigheten, 2023). Given that the species is relatively common in the local fish community, this lack of information is of particular concern.

1.2 Aim and question

The aim of this thesis is to study spawning habitat and migration pattern for ide in three streams on Gotland: Snoderån, Idån and Närkån. First, habitat mapping of the three streams was performed. Thereafter, the three streams were observed regularly to quantify the ide migration and their spawning habitat. The spawning habitat relates to the habitat mapping and will be supplemented with a description of the area (depth, water velocity, temperature and substrate etc.). Egg habitat was surveyed. After the eggs hatch, drifting fry were trapped in a fry trap between the spawning area and the sea to map the downstream migration dynamics in one of the streams.

The questions this report will focus on is:

When does ide spawn in three streams on Gotland and in what types of habitat?

When do fry start drifting downstream and how long are they?

2. Materials and Methods

This study focuses on three streams on Gotland: Idån, Närkån and Snoderån (Fig. 1). Some supplemental observations were also made serendipitously in Gothemsån, which otherwise was too large to allow for efficient observations of ide.

Figure 1: Map of Gotland with locations of streams where ide has been reported. This map was created using ArcGIS Pro (Esri Inc., 2025).

The river Snoderån is 32 km long and located in southwestern Gotland. Most parts of the river have been heavily channelised, but in some places the morphology resembles a natural stream, with apparent functional ecosystems. Regulation of the water affects the water levels in favour of irrigation for agricultural purposes. This regulation usually leads to water scarcity in downstream areas during the spring/summer (VISS, 2026a). Electrofishing surveys have caught northern pike, perch (*Perca fluviatilis*), ide, nine–spined stickleback (*Pungitius pungitius*), three–spined stickleback, and sea trout (SLU, 2025a)

The river Idån is about 27 km and located in the mid–western part of Gotland. Close to the mouth of the river, the lake–like coastal lagoon/wetland Paviken is located (the short river section between paviken and the sea is typically called paån). Paviken is considered to have high nature– and cultural values (VISS, 2026b) and is therefore and nature reserve. Today it is a regulated shallow overgrown lake with aquatic plants such as reed (*Phragmites australis*), bulrushes and cattails. The underwater vegetation is dominated by water horsetail (*Equisetum fluviatile*). Electrofishing surveys have caught perch, northern pike, ide, and roach in the river system (SLU, 2025b).

Närkån is 29 km and located in southeastern Gotland. Most parts of the river have been channelized, and the stream is running through agricultural landscape. The lower one km is affected by the sea level (VISS, 2026c). Electrofishing has caught ide, prussian carp (*Carassius gibelio*), crucian carp (*Carassius carassius*), ninespine stickleback, and tench (SLU, 2025c). Other observed fish species in the stream are northern pike, perch, roach and common rudd (*Scardinius erythrophthalmus*) (När Sockenförening, 2026).

2.1.1 Visual observation

Under favourable river conditions, visual observation is an effective method to collect information on fishes and their habitat in their natural habitat. Visual observation can be divided into three categories, surface observation, remote methods and direct underwater observation by divers (Thurow et al., 2012). Here surface observation was used from the river shore. This method is favourable when observing fish in their natural habitat with minimal disturbance (Thurow et al., 2012). In a pilot study, the method was successfully applied to document spawning ide and successful spawning (ide eggs) on Gotland in 2025 (personal communication Elida Lundgren).

A fixed observation path (Fig. A3-5) was walked along the three rivers every 2–7 days, from 11 March in Idån and Snoderån and from March 24 in Närkån to April 27. The observation paths were chosen based on recommendations from local fish expertise (Nicka Hellenberg, Peter Landergren, Elida Lundgren and Lars Vallin) and adjusted based on logistical constraints. At each visit, date, time and weather conditions were noted. When ide was observed, the approximate number of observed ides and their geographic position were noted. The approximate number of ide was estimated primarily by direct counting of all visible individuals. For large shoals, the number of individuals was estimated by counting a portion of the shoal and extrapolating the number in the portion to the whole shoal area. The association of the group with overhead cover (bridges or trees) was noted as well. Water level and water temperature was measured at one fixed point in every stream on every observation day. The proportion of observations and individuals associated with overhead cover was calculated relative to the total number of observations and individuals recorded. The availability of overhead cover was quantified by dividing the length of river path with overhead cover by the total length of the surveyed river reaches, yielding a proportion of available cover for each reach.

During surveys, general observations of potential predators for ide or eggs, such as piscivorous birds and smaller (10-20 cm) fish was noted, as well as behaviour around obstacles. A few complementary excursions to areas upstream of the observation paths, as well as to the River Gothemsån, and the presence of ide or ide eggs was noted.

One week after the spawning was observed, egg density and habitat parameters (velocity, bottom substrate and water level) were recorded at regular intervals along Idån and Närkån. In Idån, observations were made every 20 metres, reflecting the stream's greater length and relatively homogeneous habitat conditions. In Närkån, observations were made every seven metres due to the stream's shorter reach and greater habitat variability, which necessitated a higher sampling density. At every sampling point the amount of egg was categorised on a scale from 1–7 based on the amount of egg retrieved when inserting a hand into the bottom substrate. Categories correspond to absence of eggs (category 1), single or a few occasional eggs (cat 2), ten egg per hand (cat 3), 20 egg per hand (cat 4), more than 20 eggs (cat 5), eggs covering bottom (cat 6) and layers of eggs covering bottom (cat 7). The water velocity was determined using the buoyancy method. A stick was placed on the water surface and allowed to follow the current freely. The distance the stick traveled was measured to be 2 m, and the elapsed time was recorded. The velocity was then calculated according to the formula $v = s/t$, where s is the distance (m) and t is the time (s). The water depth was measured using a measuring rod that was brought vertically down to the bottom in the middle of the watercourse. Relatively few fish and no direct spawning had been observed in Snoderån, limiting egg observations to observations during the fish observation walks.

2.1.2 Fry trapping

Two weeks after eggs was first observed, a fry trap was set in Idån primarily active on weekdays from April 15 to May 29. The fry trap was placed upstream the lagoon Paviken to catch the drifting fry before they entered the lagoon. The trap consists of a rectangular metal frame with one side covered with a grid, which allows water and small animals to pass through but excludes larger organisms. From the grid opening, the water is directed through a fine–mesh cone that gradually narrows into a white plastic container, serving as a collection unit for the fry. The container is equipped with mesh on both long sides to ensure good water flow and thus an oxygenated environment for the captured fry. The trap was checked every 24 hours and was held in place with help of stones and is strategically placed in flowing water to take advantage of the natural direction of the water flow (Fig. 2). When a fry was caught, it was photographed in a see-through can with a grid of 0.5 cm squares at the bottom, allowing the total length of the fry to be measured from the photographs. The photo was scaled to actual size by measuring the squares and the size of the fry in the image. The fry trap was operated over 24 hours on 25 days, between April 14 to May 29. The fry trap was operated in accordance with ethical permission from the Swedish Board of Agriculture (Dnr 5.8.18–05864/2025).

Figure 2: Fry trap and its location in Idån. Photograph taken by Ellen Lindström.

2.1.3 Statistical analysis

All statistical analyses and all figures were done using R version 4.5.3 (R Core Team, 2025). A chi2 test was used to compare the number of fish and groups of fish observed under cover with the proportion available cover habitat. Spearman correlation was used to test the correlation between egg density and water velocities and between egg density and water depth in Idån and Närkån. The method was chosen because it can measure the relationship between two variables without requiring that the observations follow a specific distribution. Spearman corelation was also used to test if the length increased from May 8- 13.

2.1.4 Mapping of spawning habitat

The habitat mapping methodology followed the standardised format published by the County Administrative Board in Jönköping (Länsstyrelsen i Jönköpings län, 2017). The aim is to detect and map water habitats in a stream and get knowledge about the obstacles. The method is widely applied in Sweden and was included in this work to see if it can be used to inform on ide spawning habitat. The mapping of habitat was conducted from the coast to the first migration obstacle in Närkån (12 km) and Snoderån (4 km), while mapping of habitat in Idån was conducted from coast to 6 km (4 km from the lagoon Paviken). The characteristics of mapped reaches where ide or ide eggs were observed were then compared to observed reaches where no ide were observed, and with reaches not observed, and the result was discussed. For this comparison I focused on hydromorphological type, substrate, water velocity and vegetation.

3. Result

3.1 Visual observation

Ide was observed in all three streams throughout the observations period, starting from 24 March in Närkån, 11 March in Snoderån and in Idån. The number of observed ide peaked in early April in all three streams (Fig. 3). The maximum estimated number of ide observed in a river in one day was 3698 for Idån, 3257 for Närkån, and 70 for Snoderån (Fig. 3). These figures represent the sum of directly counted individuals and extrapolated estimates for large schoals. In Idån the number of ides increased rapidly on April 1 followed by a rapid decrease after April 2 (Fig. 3). Närkån had a slower increase and decrease in the number of observed Ide (Fig. 3). Snoderån showed an intermediate development but only had a much lower maximum number of ide observed per day compared to the other streams (70 vs > 3000) (Fig. 3). The spawning lasted for different lengths of time, three days in Idån and around one week in Närkån. In Snoderån no spawning was directly observed (although fish and eggs were observed).

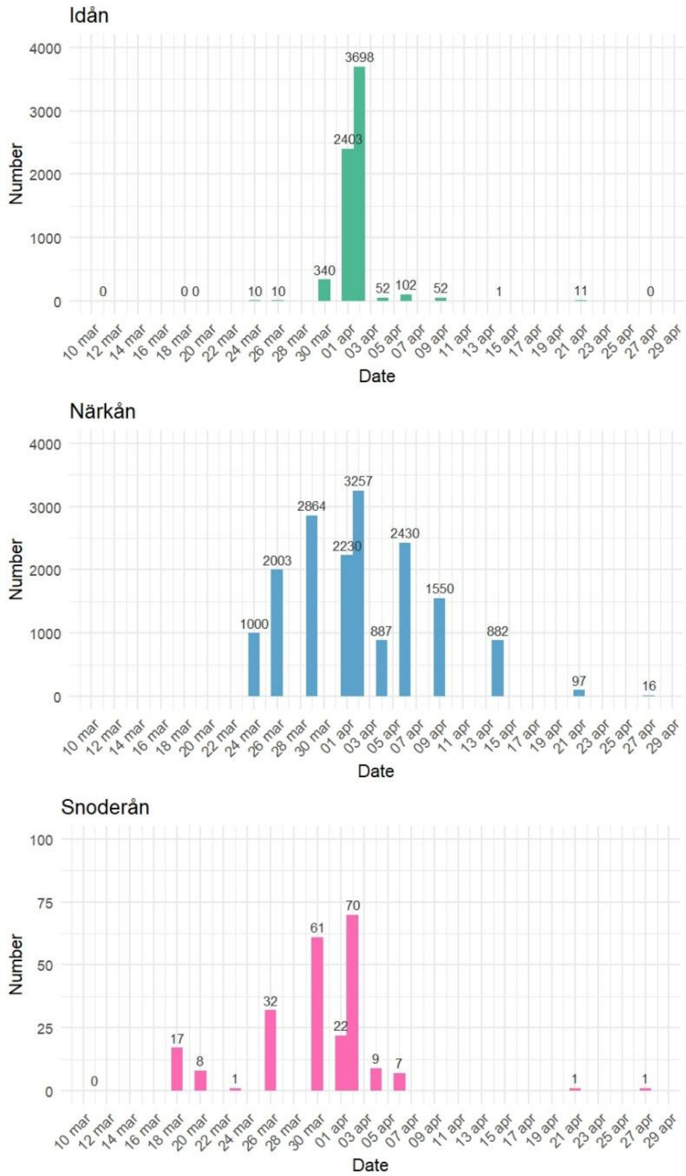

Figure 3: Total numbers of ide observed in Idån, Närkån,and Snoderån per day during visual observations. The first eggs were seen on April 1 in Närkån and Idån. In Snoderån, eggs were not observed until April 4, but this difference is likely due to difficulties observing them than later commencement of spawning in this river compared to the others. Top panel shows data from Idån, the middle panel shows data from Närkån and bottom panel shows data from Snoderån.

The visual observations revealed movement within the study area during the observational period. This was manifested by increasing number of fish higher up in the system during the peak spawning, followed by disappearance or return movement from April 2 and onwards (Fig. 4). Ides were observed in groups of 1 to 1600. Median group size was 26 (range = 1 – 1200) in Idån, 65 (range = 1 – 1600) in Närkån, and three (range = 1 – 50) in Snoderån. In only 6% (n = 13) of observations were an ide observed alone. Group sizes correlated with the total number of ide observed in the river on the day (Spearman correlation, rho = 0.83, $p < 0.001$).

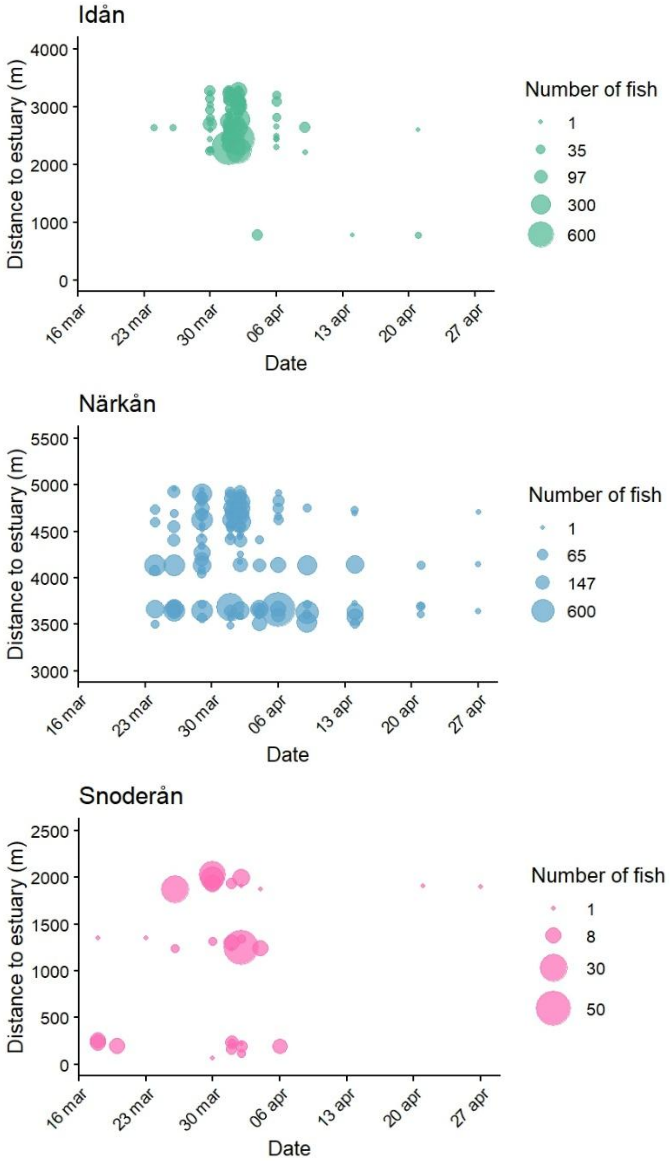

Figure 4: Upstream migration in Idån, Närkån and Snoderån. The y–axis describes the length to the estuary, and the x–axis indicate the date. The circles indicate different number of ide related to the size of the circle. The circles place in the diagram indicates how far the fish are from the estuary. Top panel shows data from Idån, the middle panel shows data from Närkån and bottom panel shows data from Snoderån.

3.1.1 Cover

Ide was observed in association with overhead cover (bridges or trees) in 29.3 % of observations, constituting 40 % of observed fish in all streams. In all streams the observed proportion under cover was higher than the expected proportion under cover based on cover proportion in the study path. This indicated a preference for overhead cover in all three streams, although this was not independent of the effect of the group itself in Idån (Table 1). The overhead cover consisted of two bridges and several trees in Idån. The overhead cover along the observation path consisted of four bridges in Närkån and trees in Snoderån.

Table 1: Chi2 test for overhead cover in Idån, Närkån and Snoderån

	Obser–vations Närkån	**Indivi–duals Närkån**	**Obser–vations Idån**	**Indivi–duals Idån**	**Obser–vations Snoderån**	**Indivi–duals Snoderån**
Observed proportion under cover	19,7%	22,0%	34,8%	50,7%	33,3%	47,2%
Expected proportion under cover	4,7%	4,7%	27,2%	27,2%	6,7%	6,7%
Chi²	59,2	11588	2	1865,5	33	597
p–value	<0,001	<0,001	0,157	<0,001	<0,001	<0,001
Statistically significant?	Yes	Yes	No	Yes	Yes	Yes

3.1.2 Water level and water depth during spawning

On April 1 the first eggs were observed. At that time the temperature was 8.5 ˚C in Idån, 5.9 ˚C in Närkån and 6.8 ˚C in Snoderån (Fig. 10). The peak number of observed fish occurred the following day, April 2, coinciding with the onset of spawning and temperatures of 6.6 ˚C in Idån, 9.1 ˚C in Närkån and 7.3 ˚C in Snoderån (Fig. 10). No rise in water level was observed before or during the spawning period (Fig. 10). The water level over time was stable in Idån (Fig. 10a). Närkån had more shifts in the water levels over time (Fig. 10a). In Snoderån a dam gate was closed between 24–26 march creating a steep decrease in water level (Fig. 10a). The fish that were observed during March 26 were stuck in pools since rapid decrease in water accessibility. Above the dam gate ide were also stuck. After March 26 the water levels seemed stable since water ran over the gate which added water to the lower parts of the stream (Fig. 10a). The water temperature varied during the study time but seem to increase over time in all three streams (Fig. 10b).

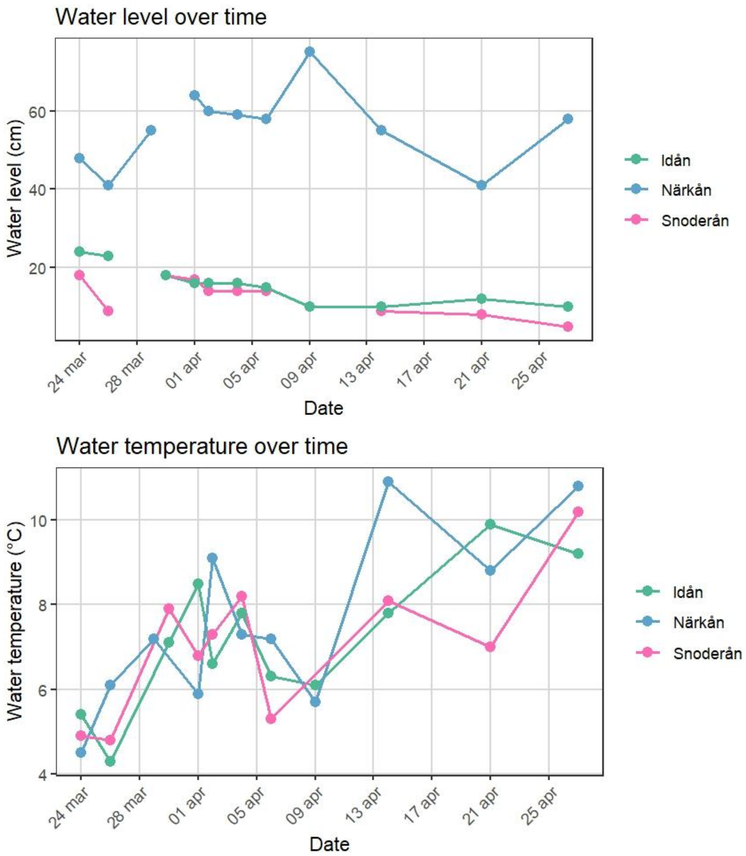

Figure 5: Relationship between water level and each observation date in top panel and between water temperature and each observation date in bottom panel. Data are shown with line chart with markers, where green colour represent Idån, blue Närkån and pink Snoderån.

3.1.3 Egg deposition

Spawning was observed from April 1 in Närkån and in Idån and the eggs seemed to increase until April 6. Egg deposition was observed over extended river reaches in Närkån and Idån (Fig. A1; Fig. A2) with variable densities. Eggs were observed in water velocities from 0.1 – 1.0 m/s, with the highest densities observed in 0.5 – 1 m/s (Fig. 5). The range of depths where eggs were found was 7 – 90 cm, with the highest densities observed at depths of 30–40 cm (Fig. 6). In Snoderån, no eggs were initially observed from the riverbank but were discovered at two places on April 4. The characteristics for these 2 places was low depth (24 and 14 cm), velocity (0.5 m/s) and stone and gravel as the dominated substrate. At every sampling point the amount of egg was categorised on a scale from 1–7 based on the amount of egg retrieved when inserting a hand into the bottom substrate (Table 2).

Table 2: The number of places within each egg category in Idån and Närkån.

Egg category	Idån	Närkån
1	22	11
2	3	0
3	4	13
4	8	16
5	6	25
6	12	4
7	8	0

Egg density increased with increasing water velocities indicating a positive correlation (Fig. 6). This correlation was significant in both Närkån (Spearman correlation; rho = 0.61, p = 2.5 e–08) and in Idån (Spearman correlation; rho = 0.39, p = 0.004).

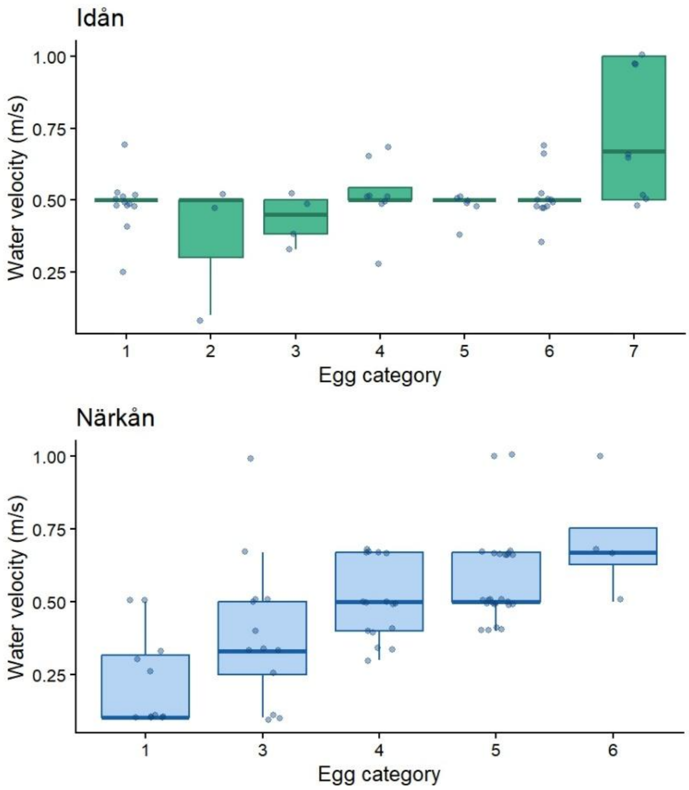

Figure 6: Relationship between amount of deposited eggs and water velocity (m/s). Top panel shows data from Idån and bottom panel shows data from Närkån. Data are summarized as box-plots (box-sections and whiskers delimit data quartiles), with raw data points shown in the background. The x-axis shows egg category between 1-7 where higher number indicates higher egg density (see Materials and methods for details).

Higher egg density decreased with increasing water depths indicating a negative correlation (Fig. 7). This correlation was tested using a Spearman correlation test in Närkån (rho = –0.51, p = 7.8 e–06) and in Idån (rho = –0.41, p = 0.002).

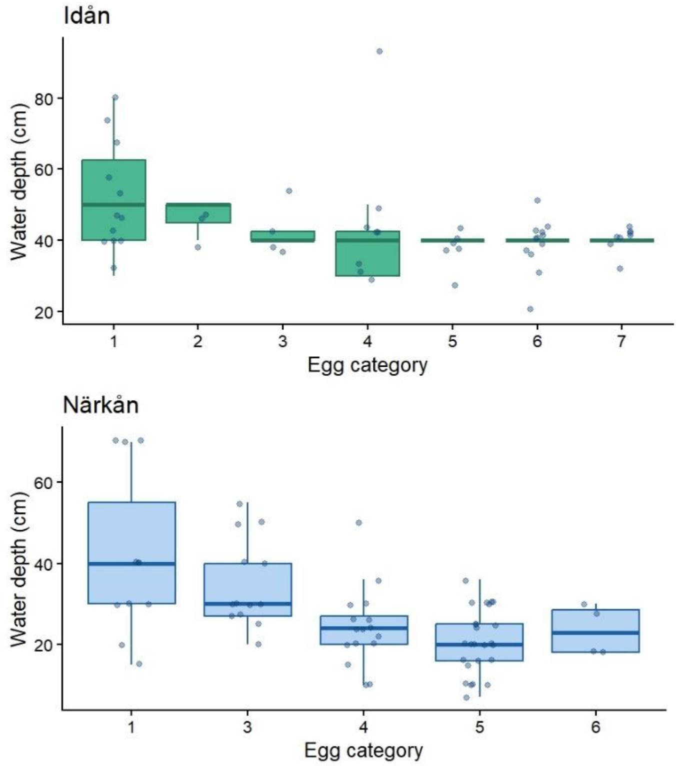

Figure 7: Relationship between amount of deposited eggs and water depth (cm). Top panel shows data from Idån and bottom panel shows data from Närkån. Data are summarized as box-plots (box-sections and whiskers delimit data quartiles), with raw data points shown in the background. The x-axis shows egg category between 1-7 where higher number indicates higher egg density (see Materials and methods for details).

Eggs were found over a multitude of different substrate types (Fig. 7). The substrate where the highest densities of eggs (egg category = 6– 7), was observed consisted of block, gravel and stone in Närkån and the same substrate types, along with bedrock, sand, silt and vegetation, in Idån (Fig. 7).

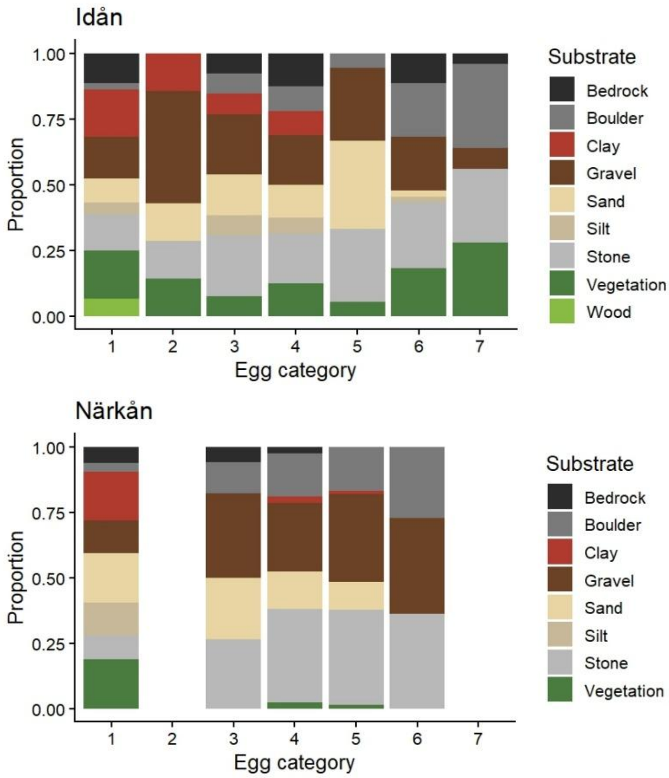

Figure 8: Substrate composition per egg category. Top panel shows data from Idån and bottom panel shows data from Närkån. The proportion of the substrate is the y–axis, and the x-axis shows egg category between 1-7 where higher number indicates higher egg density (see Materials and methods for details).

3.2 Fry trapping

The watercourse width at the trap location varied between approximately 3.5 and 4 m, and water depth varied between approximately 5 and 28 cm during the trap's active period. The trap was placed roughly in the middle of the watercourse, where flow velocity was highest, with its base resting on the streambed. The metal frame forming the trap opening measured 29 × 29 cm, exceeding the maximum recorded water depth (28 cm) at all times, meaning the trap fished the entire water column (i.e. no fry could pass over or under the trap; passage was only possible at the sides, outside the width covered by the frame).

The first fry was trapped on May 8 which was five weeks after spawning was seen (Fig. 8). The fry drift peaked on May 22 with 98 individuals that were captured (Fig 9). Other organisms that were caught were small trout (March 30, May 14), roach (March 28, May 11), perch (May 20), newt, house centipede, leech, woodlouse, snails, dragonflies, diving beetle, earwig, ladybird, backswimmer. Over time the mean size of the fry seemed to slightly increase until May 13 (Spearman correlation, rho = 0.51, $p < 0.001$). From May 20 onwards, shorter fry were then captured, and from May 26 longer and shorter fry were captured (Fig. 10).

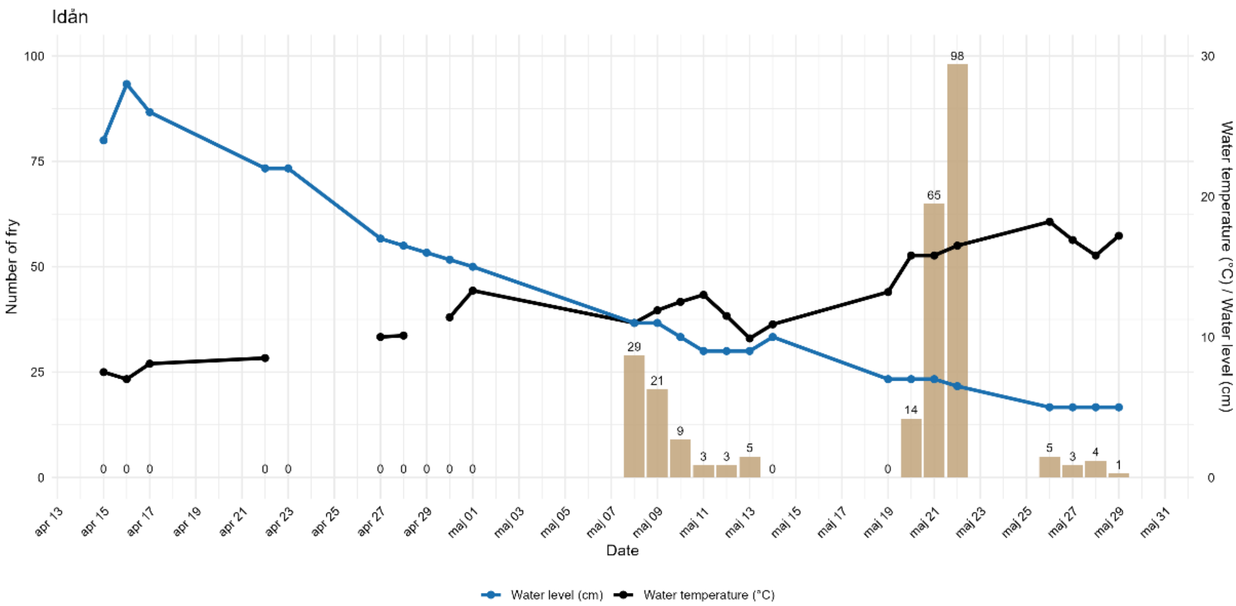

Figure 9: The water depth and water temperature on y–axis related to the date on the x–axis shown with line chart with markers. The bars represent the number of fry that was captured in the trap at different dates.

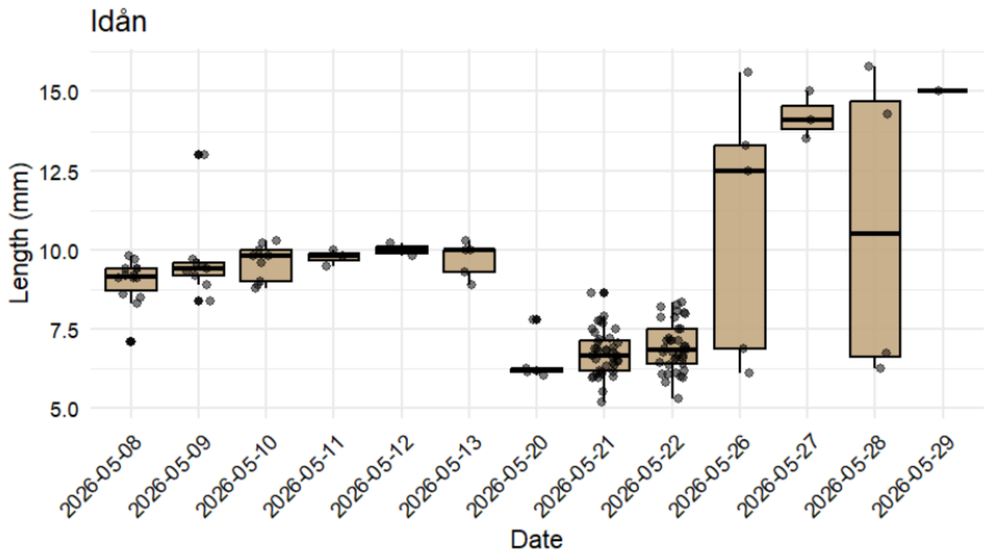

Figure 10: Relationship between the length of the fry that was captured in the trap and the date. Data are summarized as box-plots (box-sections and whiskers delimit data quartiles), with raw data points shown in the background.

3.3 General observations

During the observation period predation towards ide was observed such as, sea eagle (*Haliaeetus albicilla*), golden eagle (*Aquila chrysaetos*), grey heron (*Ardea cinerea*) and mink (*Neogale vison*). Regarding predator fishes, trout and smaller ides (10–20 cm) were observed after the eggs were laid. Predation signs such as scales were observed along the paths and some dead fish were also found, especially in Närkån on April 21 after the water level was decreasing from April 14. Fish with predation scars and fungal was also observed. In Närkån people came and watched ide which didn't seem to affect the fish when they didn't go down in the water to grab them or hunt them. A natural migration obstacle was a bedrock creation in Närkån that was between 20–40 cm high. Some ide were observed to jump over this obstacle but many failed repeatedly during the observations, apparently due to low water levels just upstream the obstacle. At one site in Gothemsån, thick layers of eggs were observed on March 31, along with a few groups of ide, indicating that peak spawning had occurred at the observation site, but this river was not followed in any detail. During opportunisitic visits to river reaches in Snoderån, Ide was observed 3.7 km from the river mouth, showing that our observation routes did not constitute the upper most extent of the ide migration. In Idån, ide was observed 6.1 km from the river mouth (3.8 km from the lagoon), showing that our observation routes did not constitute the upper most extent of the ide migration.

3.4 Habitat mapping

In Idån ide swam passed habitat EX (Meandering alluvial streams) and spawned in Bp (Turbulent steep streams with stones and boulders, with plane bed stream) and in Fö (Incised alluvial streams) habitats. In Närkån the ide swam through Ex habitat and spawned in Cx (Riffle-pool stream) habitat. In Snoderån the most different habitat types were observed and eggs were found at Cv (Riffle-pool stream, with riffle-pool stream) (Fig. A1– A5) (Table A.2-4).

4. Discussion

Ide migration and spawning was observed using the chosen observation method. On April 2 the maximum number of fish was observed 3698 in Idån, 3257 in Närkån and 70 in Snoderån. The longest observed upstream movement from the sea during this time and in the observation paths was 3.3 km in Idån, 4.9 km in Närkån and 2 km in Snoderån. Spawning was first observed on April 1 in Idån and Närkån, in temperatures between 5.9–8.5 ˚C. The spawning occurred on shallow bottoms containing mostly stone, gravel and blocks with high velocity.

4.1 Ide migration

4.1.1 Timing and duration of spawning

Before April 2, ide begun to migrate up in the waterways and started gathering. The first observations of spawning occurred on April 1 in different temperatures depending on the stream, 8.5 ˚C in Idån, 5.9 ˚C in Närkån and 6.8 ˚C in Snoderån. The observed spawning lasted around 3 days in Idån and around one week in Närkån and the spawning correlated well with the higher number of ide during this time. In Snoderån no spawning was directly observed (although fish and eggs were observed). The fact that ide spawned around the same time but at slightly different temperatures is interesting. Rohtla et al. (2021) state that spawning use to be triggered by water temperature while at the same time reporting spawning temperatures between 4 –13 ˚C and spawning occurring from March to June. In Kävlingeån spawning began 2–3 days after the temperature had reached and remained above 5 ˚C (Cala 1970b). Most ide spawned for 2–3 days when temperature rose to 7 ˚C (Cala 1970b). If the temperature dropped during spawning the spawning stops and takes place again when the temperature rises (Cala 1970b). In south Sweden the spawning takes place in March but in the north, it takes place in June (reviewed by Cala 1970b). In central Sweden spawning is reported to occur at the end of April (reviewed by Cala 1970b) and that the peak lasts for 3 days (reviewed by Cala 1970b). In Denmark the spawning occurred at 6 – 10 ˚C in March/April (reviewed by Cala 1970b). In another report the result said that the timing varied with size, ide above 1 kg spawned in March – April while the smaller ones spawned in middle of April in Estonia (reviewed by Cala 1970b). Overall, our samples of three rivers on Gotland, underlines that ide highly synchronized in spawning time but flexible in relation to river temperature during spawning. Possibly showing that day length within a temperature range may govern the timing of spawning.

4.1.2 Spawning ground

The spawning occurred in relatively high-water velocities areas (>0,5 m/s) with lower depths (<40 cm) and the spawning ground consisted mostly of block, stone and gravel in Idån and Närkån. This habitat also corresponds to where eggs were found in Snoderån (where spawning was not directly observed). The spawning ground alines with the description from the relatively nearby river Kävlingeån (Cala, 1975) where spawning occurs in shallow areas (0,5–1,5 m) with stone and gravel sediment and elements of vegetation, in flowing freshwaters. Kullander et al. (2012) state that the spawning occurs on shallow stream sections over gravel and grass bottoms. It is also reported that ide can show some flexibility regarding spawning sites, flodded grass, pebbles, pebbles with algae and plants associated with sand (Staff, 1950 ; Brylinska, 1986). In Estonia, the spawning happens on algae or sandy/stony bottoms which also occur for Idån where the higher egg category (6, 7) was observed at block, gravel, stone, sand, silt, vegetation and bedrock (Rohtla et al., 2021). Spawning success is reported to depend on stable temperatures after spawning since a considerable loss is reported if temperature drops below 5 °C, deficiency in oxygen supply and predation (Cala, 1970b).

4.1.3 Egg Development

As for fish in general, the time from spawning to hatching varies with temperature (Rothla, 2021). This development time has been described to last around 2 weeks under temperatures of 10–12 ˚C (Järvalt et al. 2003). This corresponds to degree days of 140–170. For mean temperature 10.2 ˚C it took 12.7 days which corresponds to 129 degree days and for 10.1 ˚C it took 17 days which corresponds to 172 degree days. When the mean temperature was 9.3 ˚C it took 23 days resulting in 213 degree days (Cala 1970b). Water temperature during the spawning period (April 1–27, measured on 8 occasions) averaged 8.2 °C in Närkån, 7.5 in Snoderån and 7.8 in Idån. This would correspond to hatching 26-28 days after spawning according to previous stated relationship between degree days (213) and temperature (7.5-8.2 ˚C). But the first fry was observed 36 days after spawning which results in 270–295 degree days since the spawning was seen on April 1 and the first fry was observed 7 may. One explanation for this discrepancy is that the reference value assumes a constant temperature, whereas field temperatures fluctuated over time. Since embryonic development is not linearly related to mean temperature, periods of lower temperatures may have slowed development disproportionately, and some fry may have remained upstream in the substrate without yet being entrained in drift. The low numbers of drifting fry observed may further indicate that the bulk of downstream drift occurs later still, that trap efficiency was low, or that eggs experienced a high failure rate.

4.1.4 Overhead cover

In all streams, the observed proportion of individuals were higher than the expected proportion under cover based on cover proportion in the study path. In Närkån and Snoderån the observed proportion of sites were higher than the expected proportion under cover based on cover proportion in the study path. This result is probably because Idån has a significantly higher cover proportion (27.2%), which makes the deviation proportionally smaller and requires more observations to be detected statistically. The number of observations was used as the measure of overhead cover use, rather than the number of individuals, since fish within a group are not independent of each other. Fish may follow conspecifics to a location rather than independently seeking overhead cover, which could inflate individual counts. Ide are known to exhibit shoaling behaviour and may prefer overhead cover as it provides protection from aerial predators such as grey heron and eagles, and shade, which may be particularly important for ide as a visually dependent predator.

4.2 Fry trapping

The literature is vague on the timing of habitat shift (from freshwater to marine), ranging from months in Kävlingeån (Cala, 1970b) to a few weeks regarding Rohtla et al. (2015) that state that in natal sites, located in the Väinameri Sea (West Estonia), 95% of young of the year emigrated within the first month post hatch. The trap captured 260 fry in total and the first fry was captured in the trap on May 8 around five weeks after spawning was first observed. Fry drift was observed for three weeks and drifting fry were still observed at the termination of the survey period. The result suggests that the longer ones are the last one leaving but short one can also leave late. Presumably, this depends on where in the river the fry were born, with growth rate likely being a major contributing factor. At least some fry, drift downstream relatively shortly after the starting to swim. According to laboratory results the fry length should be between 5.8–6.4 mm when hatching. During the first 56 hours the growth rate was reported 1.1 mm per hour but then the 6 day it decrease to 0.2 mm per 24 hours (Cala 1970b). A newly hatches larva measured 6 mm while a three days old measured above 6 mm (reviewed by Cala 1970b). Another source says 7 mm when hatching and 10 mm in 15–20 days (reviewed by Cala 1970b). A different source state 6.5 mm when hatching, 7 mm after twelve hours and 7.5 mm after 48 hours (reviewed by Cala 1970b). In Kävlingeån in early November fry had a mean total length between 6.8 and 7.6 cm and an individual length between 5.5–9.5 cm (Cala 1970b). The question is open weather this drift constitute active migration towards the sea or simple displacement within the stream. Future studies should monitor drifting fry for a longer period, and in different streams, to better understand the downstream migration of ide fry.

Egg density categories 1–5 were assessed per handful, while categories 6–7 represented cases where eggs covered the bottom substrate. The egg density category (1–5) recorded per substrate type may be affected by small-scale variation in egg distribution, since samples were taken at fixed intervals from the middle of the watercourse, rather than continuously across the full width and length. The sampling intervals were paced out and the midline visually judged by the field worker, which introduced further imprecision in both spacing and location. Within a sampling point, the exact spot for the handful sample was not selected based on a visual assessment of representativeness. This means sampling was effectively random within each point rather than deliberately targeted, which likely reduced the risk of a systematic bias towards visually egg-rich patches, but at the same time made the recorded density more sensitive to chance small-scale variation in egg distribution. If eggs were unevenly distributed at a fine spatial scale, the sample could by chance fall in an area with higher or lower egg density than the surrounding stretch. Since density rather than total egg count was assessed, variation in handful size (e.g. due to differences in hand size) is not expected to have affected the results. Additionally, the boundaries between adjacent density categories (2-5) were not always clearly defined, which may have introduced further inconsistency.

4.2.1 Fry catches

Idån was the stream where most eggs were observed but the fry trap only captured 260 fry. This can be due to fish not drifting downstream in large numbers, the trap not capturing fry at a high efficiency, or high mortality of eggs and young fry. The water level decreased during the fry trap period which usually is a trigger for the fry to swim out (Fig. 9). The trap was placed in a flowing part of the stream which should make it efficient, unless fry migrate on more towards the stream banks (Pavlov & Mikheev, 2017). A layer of silt was created on the eggs in the lower parts preventing oxygen. The proposed measure to address this problem is to prevent erosion from the steep sides of the drainage ditch. But it would be interesting to follow up to compare both hatching success and drift dynamics in the two rivers.

4.3 Method

During the observation period observations like estimated numbers of fish, egg density, predation marks, fish with fungal infection and fish with scars have been seen. The method has advantages like non–disturbance of spawners and no collection or handling of the fish (Palmas et al,. 2023) and it is a fast and cost–effective method to collect large amounts of information over extended periods, especially in relation to electric fishing (Bozek & Rahel, 1991; Brewer & Ellersieck, 2011). Other advantages include the flexible possibility to collect field observations of ecological interactions like predation marks and an extensive exposure of real–world conditions for the observer (Heggenes et al., 1991). There are also considerable uncertainties with this method since one must estimate the number of observed fish when they appear in bigger groups where individuals cross paths and move in different directions. At times, this leads to difficulties in assessing the exact group sizes This means that the observed number of fish, especially when numbers are high, should be interpreted as the approximation that it is. Other potenital biases include that it is easier to see larger individuals, moving individuals and individuals that are visible from above (compared to those that are hiding in e.g. vegetation) (Brewer & Ellersieck, 2011). Environmental conditions such as wind, turbidity and light also effect the possibility to see fishes (Brewer & Ellersieck, 2011). The method gives semi-quantitative rather than quantitative data, providing the basis to understanding larger–scale patterns rather than providing exact data. Thurow et al. (2012) described the method in the same way, adding advantages at shallower depths and migration monitoring, and disadvantages in dense vegetation and for fish that are easily frightened. Despite its limitations, this method was the most suitable choice for this study, as it effectively captures migration patterns during spawning, group migration, and the use of overhead cover.

4.4 General observations

4.4.1 Ide jumping performance

Jumping performance determine which obstacle fish can negotiate. Whereas salmonids are known good jumpers, and juvenile eels can climb over moist structures in air, European cypriniforms are typically considered weak jumpers (Baudoin et al., 2015). In some conditions, ide were observed to jump over a bedrock creation in Närkån. In total, I only observed four individuals succeeding the jump during my observation occasions, while many more failed. The obstacle was between 20–40 cm high and the water depth above the obstacle was approximately ten cm for 50 meters and the water velocities was high around 1–2 m/s. The literature state that an obstacle of 20 cm is 100 % passable for ide and some can jump over an obstacle of 50–70 cm (Baudoin et al., 2015). Hence, the results correspond with the literature, but it is important that the water depth and the water velocity after the obstacle also seems to play a role for the rate of success.

4.4.2 Predation on Ide and eggs

In all three streams piscivorous birds like grey heron and eagles was spotted. Observations of eagles eating the ide and scales along the path was also observed along with mink. Observations of smaller ides was seen after the spawning occurred in both Närkån and Idån which probably means that the younger ide eat eggs. The big amount of ides in different sizes is also an important food resource for the ecosystem especially the piscivorous birds. Migration plays an important role in energy transfer between ecosystems (Lucas & Baras, 2001). Salmonids are among the migratory fishes that contribute significantly to nutrient and energy flux between marine and freshwater systems (Haskell, 2018; Cederholm et al., 1999). Eggs, fry, and carcasses serve as food sources for a range of species, and the growth rate of juvenile salmonids has been shown to double following spawning events of adults salmon in the area (Cederholm et al., 1999). Piscivorous fish such as pikeperch, are known to follow migrating trout smolt (Lucas & Baras, 2001). Concentrations of fish in restricted areas also attract piscivorous birds; salmonid eggs and carcasses are exploited by species including eagle and gulls (Cederholm et al., 1999), and grey heron are known to aggregate where fish become accessible in shallow water (Lucas & Baras, 2001).

4.4.3 Migration before observation

Ide were observed in the streams from the onset of the observational period until its end in Närkån and Snoderån, with an initial increase in numbers followed by decrease as the study progressed. In Idån the first two observation weeks resulted in zero ide observations. None of the river surveys included the river stretches closest to the sea. This was because they were unlikely to hold important spawning sites in Närkån (personal communication Nicka Hellenberg) and the lower sections were also inconvenient for visual observation of fish in Idån (deep and wide), and difficult to access in Snoderån. This means that arrival to the study reach does not necessarily equal arrival to the river. Ide has been reported to migrate upstream both in spring and in the preceding autumn (Rohtla et al., 2015). Especially in Idån, it is not unlikely that ide arrived to the lagoon Paviken already in the autumn. If so, the ide would stay in the lagoon during the winter and continue their upstream migration in spring. The Swedish Anglers Association in Gotland operated a fyke net at the lagoon outlet, from March 18 to April 22 2026, and only captured ten ide in this net. Over 3000 ide were observed in the study reach upstream, so either they swam around the fyke net (negotiating a barrier next to the fyke net), or they had passed into the lake already in the preceding autumn. In spring 2023, from March 16 to April 24, the same fyke net captured 184 ide, while 361 ide were captured during the preceding in autumn (Sportfiskarna, 2023), indicating at least an important autumn migrating component of the ide population. Future telemetry studies could be used to explore how individual migrate before and after spawning (Thorstad et al., 2013).

4.5 Habitat mapping

Assumptions that can be made based on these results are that spawning can take place in Fö habitats (Incised alluvial streams) which occurred in Idån. This assumption probably makes both ide number and spawning locations more then what was investigated in this study either because it is an overspill effect from preferable habitats nearby or because they can spawn in these areas. In Snoderån the spawning and more ide should probably be seen in Ex (Meandering alluvial streams) and Cv (Riffle-pool stream, with riffle-pool stream) habitats lower than my observation paths but they were inaccessible. Snoderån was the only place where observation of eggs on Ex habitat was done which resulted in seeing eggs on vegetation (egg category 2–3). I observed ide and eggs in Idån above the observation area one time in Bp (Turbulent steep streams with stones and boulders, with plane bed stream) habitat and its reasonable to say that ide can probably spawn higher up in the Fö (Incised alluvial streams) areas as well since observation of ide and spawning was made in the lower parts. After the bedrock obstacle in Närkån there is a long Fö path (10 km) and then a Cv (Riffle-pool stream, with riffle-pool stream) habitat where ide probably can spawn and stay in. The conclusion is that ide probably can occur and spawn in areas upstream my observation paths in Idån and Närkån since Bp and Cv habitats occur there since observation of ide and eggs were made downstream. In Snoderån it seems likely that ide spawn and occur in Cv and Ex habitats closer to the mouth but these areas were inaccessible. Ex (Meandering alluvial streams**)** habitat does not seem to be preferable, but observations in Snoderån prove that ide and eggs can occur in Ex habitat. The reason that I did not observe Ex habitats in Idån and Närkån is that those parts were deep and wide, which did not correspond to the chosen method.

4.6 Conservation measures in the streams

To best preserve ide populations, measures to protect or restore spawning habitat are likely necessary, as improving spawning substrate has been shown to increase recruitment success in rheophilic cyprinids (Pander et al., 2022). Post-spawning monitoring is recommended to evaluate spawning success. In this study, a fry trap was deployed to detect the presence and density of fry. Alternatively, electrofishing can be used for the same purpose (Bergquist et al., 2014). This report also shows that many fish were under overhead cover which emphasizes the importance of trees and bridges. Since spawning occurs in shoals, it occasionally gets a lot of attention from the public. This means that it is important to either regulate fishing at spawning time or at least make people aware of the importance of spawning for maintaining the fish population. Under the dam gate in Snoderån, some measure that maintains a suitable downstream water level should be prioritized. This year the water ran over the dam gate after its closing keeping the supply of water to the lower parts of the stream but in 2025 the closure of stream flow led to standing and death for several fish (SR 2025).

4.7 Future studies

Future studies that would be interesting are to search for ide spawning in river sections more connected to agriculture where the majority of the bottom substrate is clay and drained environments. Does vegetation play a greater role or do they migrate to rocky bottoms and does spawning happen successfully? Future telemetry studies could be used to explore how individuals migrate before and after spawning and to see if homing behaviour exists (Thorstad et al., 2013). Other methods that would be interesting in the future is scale reading to see what age the ide spawn and if that changes in different streams and along fish (Bagenal & Tesch, 1978) and otolith chemistry to see the timing of downstream migration (Campana, 2001). It would also be interesting to identify the obstacle limit height for the ide and other biotic factors that affect the jumping ability, like water depth and water velocities before and after the obstacle.

4.8 Summary

To conclude the spawning was first observed on April 1 where different temperatures was measured in the three streams (5.9- 8.5 ˚C). Timing, spawning and the temperature reach aligned with the literature. The spawning took place on stone, gravel and block bottom with lower depth (<40 cm) and higher velocities (>0,5 m/s) which also correlated well with the literature. Downstream moving fry were caught 5 weeks (35 days) after spawning was observed in Idån. According to the literature, egg development under the observed temperatures should take 26-28 days. The delayed emergence and low drift catches indicate that egg development was slower than literature values predict, likely reflecting field temperature fluctuations. Drifting fry (260) ranged in body length from 5 to 16 mm across the three-week observation period, suggesting variation in both hatching time and growth rate among individuals. Future research using telemetry techniques could be used to explore how individuals migrate before and after spawning and if they show homing behaviour.

Acknowledgement
I would like to thank my supervisors Daniel Nyqvist and Joacim Näslund for their guidance, and valuable comments throughout the period. I would also like to thank Nicka Hellenberg, Peter Landergren and Lars Vallin for information connected to Gotland and the ide. Lastly, I would like to than Elida Lundgren for help regarding the habitat mapping.

References

Baudoin, J.–M., Burgun, V., Chanseau, M., Larinier, M., Ovidio, M., Sremski, W., Steinbach, P. and Voegtle, B. (2015) *Assessing the passage of obstacles by fish: concepts, design and application. The ICE protocol for ecological continuity*. Onema.

Bagenal, T.B. and Tesch, F.W. (1978) 'Age and growth', in Bagenal, T.B. (ed.) *Methods for Assessment of Fish Production in Fresh Waters*. 3rd edn. Oxford: Blackwell Scientific Publications, pp. 101–136.

Bergquist, B., Degerman, E., Petersson, E., Sers, B., Stridsman, S. and Winberg, S. (2014) *Standardiserat elfiske i vattendrag: en manual med praktiska råd*. Aqua reports 2014:15. Drottningholm: Sveriges lantbruksuniversitet.

Bonow M, Svanberg I. 2013. Karpfiskarnas tillbakagång i svenskt kosthåll. Ur: Rytkönen P, Bonow M, Wramner P, (red.), Från matproduktion till gastronomi. Huddinge: Södertörn University, pp. 91-114.

Bozek, M. A., & Rahel, F. J. (1991). Comparison of Streamside Visual Counts to Electrofishing Estimates of Colorado River Cutthroat Trout Fry and Adults. *North American Journal of Fisheries Management*, *11*(1), 38–42. https://doi.org/10.1577/1548–8675(1991)011%3C0038:COSVCT%3E2.3.CO;2

Brewer, S. K., & Ellersieck, M. R. (2011). Evaluating two observational sampling techniques for determining the distribution and detection probability of age–0 Smallmouth Bass in clear, warmwater streams. *North American Journal of Fisheries Management*, *31*(5), 894–904.

Brylinska, M. (1986) *Ryby Slodkowodne Polski*. Warszawa: PWN.

Brönmark, C., Skov, C., Broderson, J., Nilsson, P.A. & Hansson, L.A. 2008. Seasonal Migration Determined by a Trade–Off between Predator Avoidance and Growth. PLoS ONE 3 (4): e1957. https://doi.org/10.1371/journal.pone.0001957

Cala, P. 1970 a. The development of the oocytes and seasonal changes in the ovary of the ide Idus idus (L.) in the river Kävlingeån, South Sweden. Caldasia 10 (50): 579−594.

Cala, P. 1970 b. The ecology of the Idus idus (L.) in the River Kävlingeån, South Sweden. Report from the Institute of Freshwater Research, Drottningholm 50: 45−99.

Cala, P. 1975. Age at maturity, testicular development and seasonal changes in the testes of the ide Idus idus (L.) in the river Kävlingeån, South Sweden. Report from the Institute of Freshwater Research, Drottningholm.

Cederholm, C.J., Kunze, M.D., Murota, T. and Sibatani, A. (1999) 'Pacific salmon carcasses: essential contributions of nutrients and energy for aquatic and terrestrial ecosystems', *Fisheries*, 24, ss. 6–15.

Esri Inc. (2025) *ArcGIS Pro*, version 3.x. Redlands, CA: Environmental Systems Research Institute. Available at: https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview

FishBase. 2026. FishBase, version (02/2026). Online publication. https://www.fishbase.org/

Fiskdata.se. 2026. Följ fiskvandringen på fiskdata.se. FISKDATA [2026–05–20]

Haskell, C.A. (2018) 'From salmon to shad: shifting sources of marine-derived nutrients in the Columbia River Basin', *Ecology of Freshwater Fish*, 27(1), ss. 310–322.

Havs– och vattenmyndigheten (2023). *Åtgärdsprogram för vimma och id. Rapport 2023:1.* Göteborg: Havs– och vattenmyndigheten. Tillgänglig på: https://www.havochvatten.se/download/18.fe779651861e7d74903a765/1675859509747/rapport–2023–1–atgardsprogram–agp–hav–vimma–id.pdf (Hämtad: 20 01 2026)

Hawkins, A. D. & Smith, G. W. (1986) Radio–tracking observations on Atlantic salmon ascending the Aberdeenshire Dee. Scottish Fisheries Research Report, 36.

Heape, W. (1931) Emigration, Migration and Nomadism. Heffer, Cambridge.

Heggenes, J., Brabrand, Å., & Saltveit, S. J. (1991). Microhabitat use by brown trout, *Salmo trutta* L. and Atlantic salmon, *S. salar* L., in a stream: A comparative study of underwater and river bank observations. *Journal of Fish Biology*, *38*(2), 259–266. https://doi.org/10.1111/j.1095–8649.1991.tb03112.x

Jonsson, N. (1991) Influence of water flow, water temperature and light on fish migration in rivers. Nordic Journal of Freshwater Research, 66, 20–35.

Järvalt, A., Palm, A & Turovski, A. 2003. Ide, Leuciscus idus (L.). I: E. Ojaveer, E. Pihu, & T. Saat (red.). Fishes of Estonia. Estonian Academy Publishers, Tallinn, sid. 179−183.

Kulíšková P, Horky P, Slavık O, Jones JI. 2009. Factors influencing movement behaviour and home range size in ide Leuciscus idus. J Fish Biol. 74 (6):1269–1279. doi:10. 1111/j.1095–8649.2009.02198.x

Kullander, S. O., Delling, B., Nyman, L., & Jilg, K. (2012). *Nationalnyckeln till Sveriges flora och fauna. Ryggsträngsdjur: Strålfeniga fiskar. Chordata: Actinopterygii*. Uppsala: SLU Swedish Species Information Centre, Swedish University of Agricultural Sciences. Flecker, A.S., McIntyre, P.B., Moore, J.W., Anderson, J.T., Taylor, B.W. and Hall, R.O. (2010) 'Migratory fishes as material and process subsidies in riverine ecosystems', *American Fisheries Society Symposium*, 73, pp. 559–592.

Lucas, M.C. & Baras, E. (2001). *Migration of Freshwater Fishes.* Oxford: Blackwell Science. doi:10.1002/9780470999653

Länsstyrelsen i Jönköpings län (2017). *Biotopkartering vattendrag. Metodik för kartering av biotoper i och i anslutning till vattendrag.* Februari 2017. Meddelande nr 2017:09. Microsoft Word – Rapport biotkartering 170228 slutversion.docx

Morais, P. & Daverat, F. 2016. ‘Definitions and concepts related to fish migration’. I: *An Introduction to Fish Migration*. Boca Raton, FL: CRC Press, s. 14–19

Northcote, T. G. (1978) Migratory strategies and production in freshwater fishes. In: Ecology of Freshwater Production (ed. S. D. Gerking), pp. 326–359. Blackwell, Oxford.

Northcote, T. G. (1984) Mechanisms of fish migration in rivers. In: Mechanisms of Migration in Fishes (eds J. D. McCleave, J. J. Dodson & W. H. Neill), pp. 317–355. Plenum, New York.

När sockenförening, 2026. Fiske i Närsån. Fiske i Närsån | När

Palmas, F., Casula, P., Curreli, F., Podda, C., Cabiddu, S., & Sabatini, A. (2023). Exploring Less Invasive Visual Surveys to Assess the Spatial Distribution of Endangered Mediterranean Trout Population in a Small Intermittent Stream. *Biology*, *12*(7), 1000. https://doi.org/10.3390/biology12071000

Pander, J., Nagel, C., Ingermann, H. and Geist, J. (2022) Water level induced changes of habitat quality determine fish community composition in restored and modified riverbanks of a large alpine river, *International Review of Hydrobiology*, 107(1-2), pp. 46–59.

Pavlov, D. S., & Mikheev, V. N. (2017). Downstream migration and mechanisms of dispersal of young fish in rivers. *Canadian Journal of Fisheries and Aquatic Sciences*, *74*(8), 1312–1323. https://doi.org/10.1139/cjfas-2016-0298

R Core Team (2025) *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. Available at: https://www.R–project.org/ (Accessed: 2 June 2026).Campana, S.E. (2001) ‘Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods’, Journal of Fish Biology, 59(2), pp. 197–242. https://doi.org/10.1111/j.1095–8649.2001.tb00127.x

Rideout, R. M., Rose, G. A., & Burton, M. P. (2005). Skipped spawning in female iteroparous fishes. Fish and Fisheries, 6 (1), 50–72.

Rohtla, M., Vilizzi, L., Kováč, V., Almeida, D., Brewster, B., Britton, J.R., Głowacki, Ł., Godard, M.J., Kirk, R., Nienhuis, S., Olsson, K.H., Simonsen, J., Skóra, M.E., Stakėnas, S., Tarkan, A.S., Top, N., Verreycken, H., Zięba, G. & Copp, G.H. (2021). Review and Meta–Analysis of the Environmental Biology and Potential Invasiveness of a Poorly–Studied Cyprinid, the Ide *Leuciscus idus*. *Reviews in Fisheries Science & Aquaculture*, 29 (4), 512–548. https://doi.org/10.1080/23308249.2020.1822280

Rothla, M., Svirgsden, R., Taal, I., Saks, L., Eschbaum, R. & Vetemaa, M. 2015. Life–history characteristics of ide Leuciscus idus in Eastern Baltic Sea. Fisheries Management and Ecology 22: 239–248.

Schönhuth, S., Vukić, J., Šanda, R., Yang, L. and Mayden, R.L. (2018) ‘Phylogenetic relationships and classification of the Holarctic family Leuciscidae (Cypriniformes: Cyprinoidei)’, *Molecular Phylogenetics and Evolution*, 127, pp. 781–799. https://doi.org/10.1016/j.ympev.2018.06.026

SLU Artdatabanken (2026). *Artfakta: id (Leuciscus idus)*. https://artfakta.se/taxa/102137 [2026–05–18]

SLU (2025a) *Svenskt elfiskeregister – SERS – station Borum (6346570–1641950)*. Uppsala: Institutionen för akvatiska resurser, Sveriges lantbruksuniversitet. Tillgänglig: slu.se/elfiskeregistret [Hämtad 20 april 2025].

SLU (2025b) *Svenskt elfiskeregister – SERS – station Svärmarbänken (6372740–1640520)*. Uppsala: Institutionen för akvatiska resurser, Sveriges lantbruksuniversitet. Tillgänglig: slu.se/elfiskeregistret [Hämtad 5 mars 2025].

SLU (2025c) *Svenskt elfiskeregister – SERS – station Dambro (6351670–1669560)*. Uppsala: Institutionen för akvatiska resurser, Sveriges lantbruksuniversitet. Tillgänglig: slu.se/elfiskeregistret [Hämtad 5 mars 2025].

Sportfiskarna (2023) *Projektredovisning bilaga 1: Plupp – Planering och uppföljning: Efter 10 år av fiskevårdsåtgärder på Gotland*. Visby, 1 december 2023. Projektledare: Lars Vallin.

SR (Sveriges Radio). 2025. Experten om torrlagda ån: ”Symtom på klimatförändringar”. Visby: Sveriges Radio P4 Gotland. https://www.sverigesradio.se/artikel/experten-om-torrlagda-an-symtom-pa-klimatforandringar[2026-06-01]

Staff, F. (1950) *Ryby Slodkowodne Polski i Kljow Osciennych*. Warszawa: Trzaska, Evert & Michilski.

Thorstad, E.B., Rikardsen, A.H., Alp, A. & Økland, F. (2013). *The use of electronic tags in fish research – an overview of fish telemetry methods*. Turkish Journal of Fisheries and Aquatic Sciences, 13, s. 881–896. https://doi.org/10.4194/1303–2712–v13_5_13

Thurow, R.F., Dolloff, C.A. & Marsden, J.E. (2012). ‘Visual observation of fishes and aquatic habitat’, i Zale, A.V., Parrish, D.L. & Sutton, T.M. (eds.), *Fisheries Techniques*, 3rd edn. Bethesda, MD: American Fisheries Society, s. 781–817.

VISS, 2026a. Snoderån–Sproge – Vattendrag – VISS – VattenInformationsSystem för Sverige

VISS, 2026b. Idå – Vattendrag – VISS – VattenInformationsSystem för Sverige

VISS, 2026c. Närkån – Vattendrag – VISS – VattenInformationsSystem för Sverige

Appendix 1

Table A. 1: Description of the Hydromorphological classification used when habitat mapping

Hydromorphological classification	Explanation
Bp	Turbulent steep streams with stones and boulders, with plane bed stream
Bt	Turbulent steep streams with stones and boulders, with step pool stream
Bx	Turbulent steep streams with stones and boulders
Cv	Riffle-pool stream, with riffle-pool stream
Cx	Riffle-pool stream
Ex	Meandering alluvial streams
Fö	Incised alluvial streams
Zz	Highly modified watercourses

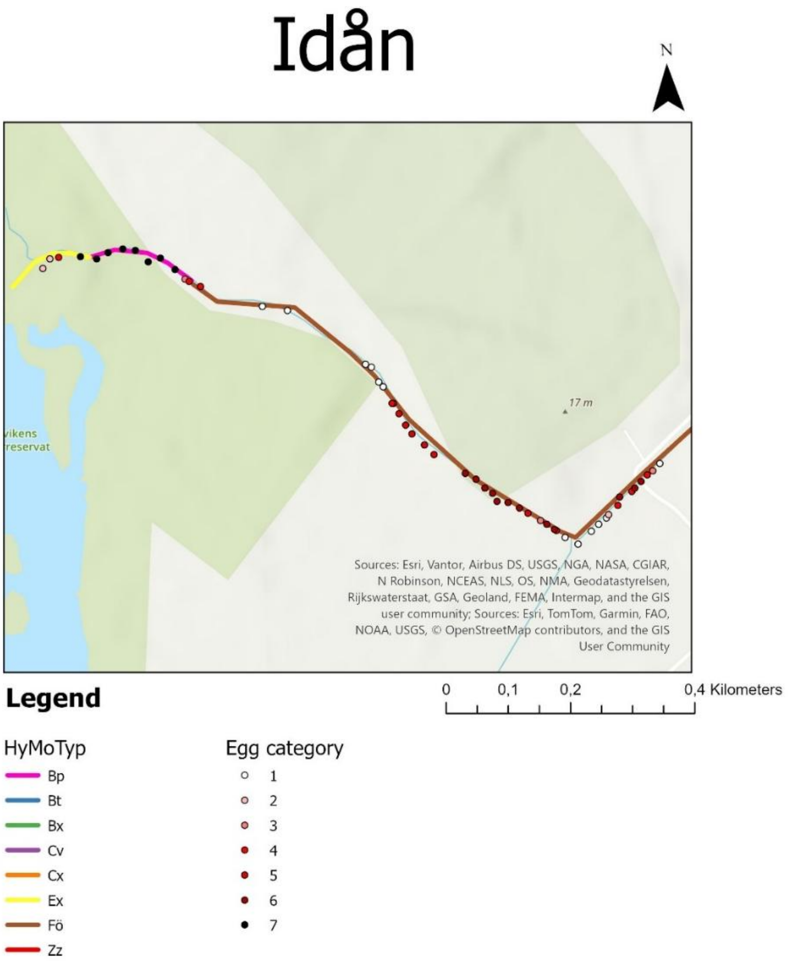

Figure A. 1: Habitat mapping connected to egg category in Idån. See material and method for explanation of egg category and Table A.1 for explanation of Hydromorphological classification. This map was created using ArcGIS Pro (Esri Inc., 2025).

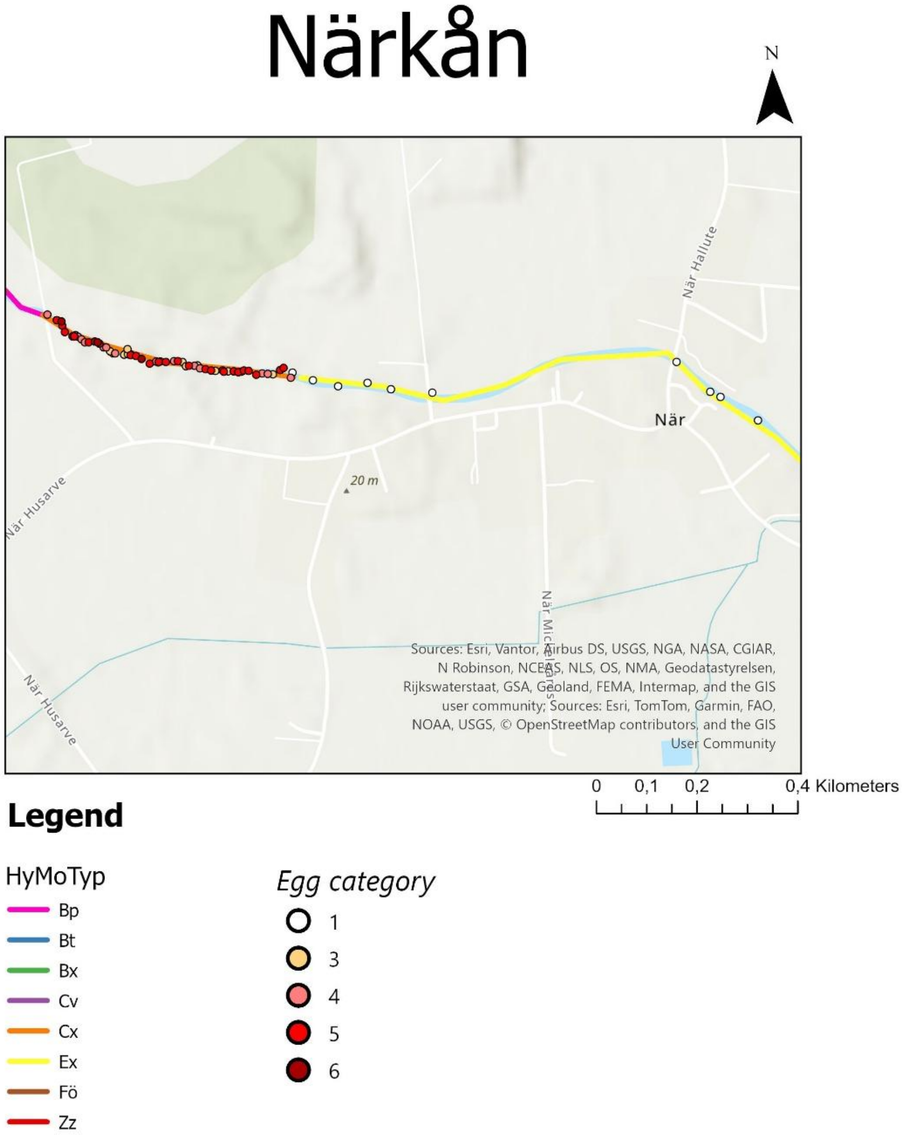

Figure A. 2 : Habitat mapping connected to egg category in Närkån. See material and method for explanation of egg category and Table A.1 for explanation of Hydromorphological classification. This map was created using ArcGIS Pro (Esri Inc., 2025).

Idån

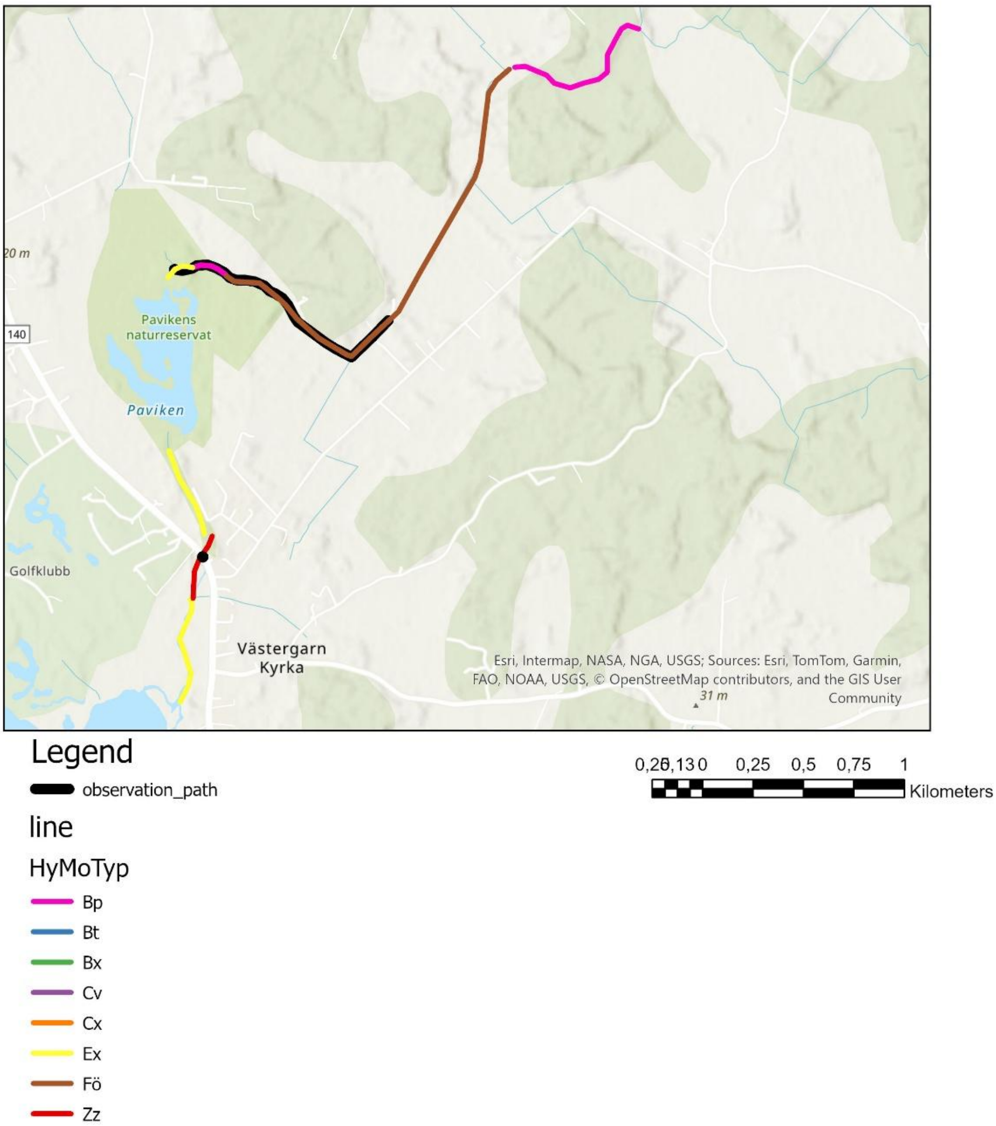

Figure A. 3: Habitat mapping of Idån. The observation paths are shown in black. See Table A.1 for explanation of Hydromorphological classification. This map was created using ArcGIS Pro (Esri Inc., 2025).

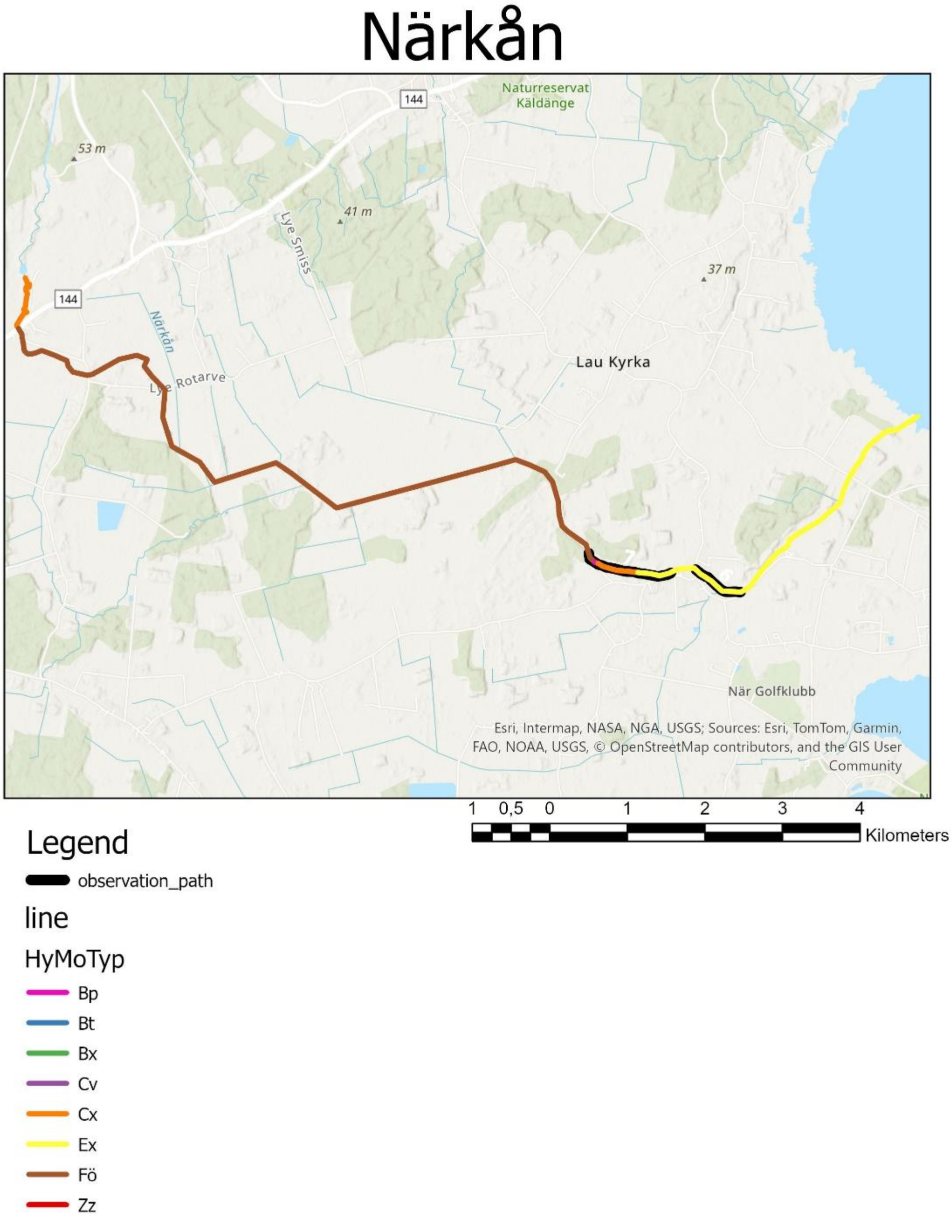

Figure A. 4: Habitat mapping of Närkån. The observation paths are shown in black. See Table A.1 for explanation of Hydromorphological classification. This map was created using ArcGIS Pro (Esri Inc., 2025).

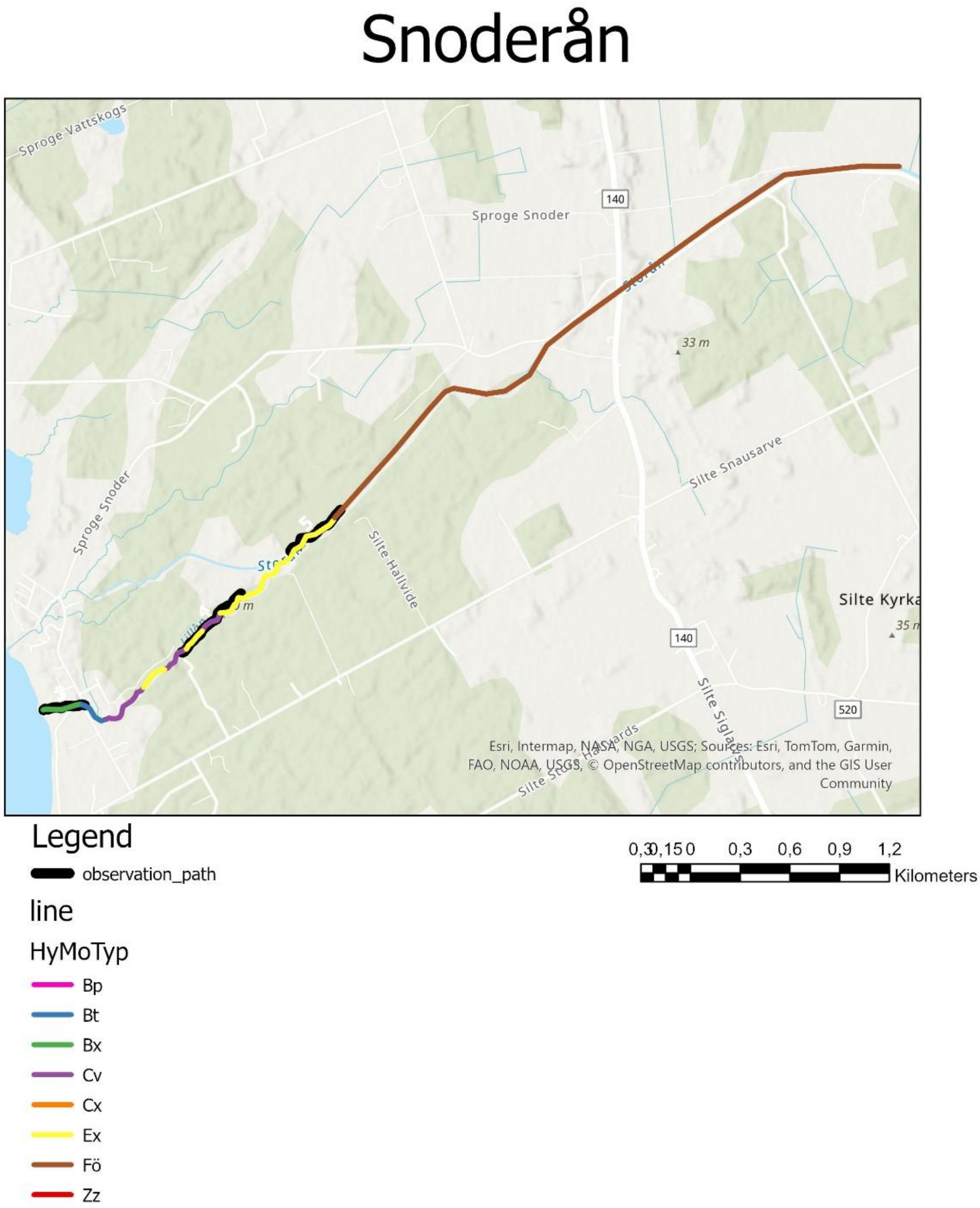

Figure A. 5: Habitat mapping of Snoderån. The observation paths are shown in black. See Table A.1 for explanation of Hydromorphological classification. This map was created using ArcGIS Pro (Esri Inc., 2025).

Table A. 2: Substrate, water velocity, vegetation, observed ide on 2 april, egg category in relation to the hydromorphological classification in Idån. See Table A.1 for explanation of Hydromorphological classification.

Idån							
Section	Length	HyMoTyp	Substrate	Water velocity	Vegetation	Observed ide april 2	Egg
1	547	EX	>50% silt, 5–50% sand, clay, fine detritus	5-50%,calm and slow-flowing	<5%	–	–
2	331	Zz	5–50% stone, gravel, sand	5-50%,calm and slow-flowing	5–50% Rooted emergent macrophytes	–	–
3	460	Ex	>50% silt, fine detritus 5–50% boulder, stone, clay	>50% calm, 5-50% slow flowing	>50% Rooted emergent macrophytes		
4	82	Ex	>50% gravel, 5–50% sand, silt, clay, fine detritus	>50% calm, 5-50% slow flowing	–	596	2-4 mean 2,7 on 3 places
5	183	Bp	>50% boulder, 5-50% stone	>50% flowing	5–50% Rooted emergent macrophytes	1030	3-7 mean 6,3 on 10 places
6	790	Fö	>50% stone, silt, 5–50% gravel, sand, clay	50% calm, 5–50% slow-flowing	5–50% whole leaves	2075	1-6 mean 3 on 39 places
7	1600	Fö	>50% stone, silt, 5–50% gravel, sand, clay	50% calm, 5–50% slow-flowing	5–50% whole leaves	–	–
8	834	Bp	>50% bedrock, 5-50% stone	50% slow, 5-50% calm-flowing	–	–	–

Table A. 3: Substrate, water velocity, vegetation, observed ide on 2 april, egg category in relation to the hydromorphological classification in Närkån. See Table A.1 for explanation of Hydromorphological classification.

Närkån							
Section	Length	HyMoTyp	Substrate	Water velocity	Vegetation	Observed ide april 2	Egg
1	4320	Ex	>50% silt, fine detrius, 5-50% clay, soarse detrius	50% calm	–	–	–
2	480	Ex	>50% silt, fine detrius, 5-50% clay, soarse detrius	50% calm	–	678	1 on 9 places
3	519	Cx	>50% stone, 5-50% boulder,, gravel	>50% flow flowing, 5-50%calm and flowing	–	2579	1-6 mean 4 on 60 places
4	94	Bp	>50% bedrock	>50% flowing	–	–	–
5	10051	Fö	>50% bedrock, 5-50% silt, coarse detrius	50% calm	5–50% Rooted emergent macrophytes	–	–
6	821	Cx	>50% gravel, 5-50% boulder, stone	>50% flow flowing, 5-50%calm and flowing	–	–	–

Table A. 4: Substrate, water velocity, vegetation, observed ide on 2 april, egg category in relation to the hydromorphological classification in Snoderån. See Table A.1 for explanation of Hydromorphological classification.

Snoderån							
Section	Length	HyMoTyp	Substrate	Water velocity	Vegetation	Observed ide april 2	Egg
1	216	Bx	>50% stone, 5-50% boulder, gravel	>50% flowing, 5-50% fast flowing	–	7	–
2	213	Bt	>50% bedrock	>50% fast flowing, 5-50% flowing	–	–	–
3	320	Cv	>50% stone, 5-50% gravel	>50% flowing, 5-50% calm and slow-flowing	–	–	–
4	177	Ex	>50% gravel, 5-50% sand, silt,clay	50% slow, 5-50% calm-flowing	5–50% whole leaves	–	–
5	179	Cv	>50% stone, 5-50% gravel, boulder	50% slow, 5-50% calm-flowing	–	–	–
6	147	Ex	>50% gravel, 5-50% sand, silt,clay	50% slow, 5-50% calm-flowing	>50% whole leaves	–	–
7	161	Cv	>50% gravel, 5-50% stone, sand, coarse detritus	50% calm, 5-50% slow-flowing	–	–	–
8	219	Ex	>50% silt, 5-50% gravel, sand, clay	50% calm, 5-50% slow-flowing	5–50% whole leaves	52	2 on 2 places
9	379	Ex	>50% silt, 5-50% gravel, sand, clay	50% calm, 5-50% slow-flowing	5–50% whole leaves	–	–
10	350	Ex	>50% silt, 5-50% stone, gravel, clay, fine detrius	50% calm, 5-50% slow-flowing	5–50% whole leaves	11	–
11	4000	Fö	>50& gravel, 5-50% stone, sand	50% calm	–	–	–

Figure A. 6: Pictures of ide and the eggs on different dates in Idån. Photographed by Ellen Lindström.