



The Atlantic spiny lumpsucker *Eumicrotremus spinosus*: life history traits and the seemingly unlikely interaction with the pelagic amphipod *Themisto libellula*

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Abstract: During a cruise to Svalbard in September 2012 a unique collection of the little known but widely distributed Atlantic spiny lumpsucker (*Eumicrotremus spinosus*) was made in the Hinlopen Strait. A total of 140 individuals (36–101mm total length) were collected using a bottom trawl. All individuals were sexed and 26 of these were also analysed for gonadosomatic index (GSI), hepatosomatic index (HSI) and stomach content. The sex ratio of the entire sample showed a strong bias towards females (75% of all examined specimens). The GSI ranged from 1.4 to 5.8% except for one female with a GSI of 20%. All females carried gonads in which eggs were clearly visible, independent of size, indicative of an early sexual maturation and an iteroparous life cycle of females. All examined specimens had almost an exclusively pelagic diet, with *Themisto libellula* constituting 100% of the stomach content in 80% of the examined fishes. The results are discussed in relation to diel vertical migration of Arctic zooplankton and deep migrating layers.

Key words: Arctic, *Eumicrotremus spinosus*, *Themisto libellula*, DVM.

Introduction

The Atlantic spiny lumpsucker, *Eumicrotremus spinosus* (Fabr., 1776) of the family Cyclopteridae is a common species in the waters around Svalbard, but very little detailed knowledge exists regarding its life history, feeding and reproductive biology. *Eumicrotremus spinosus* was first established as a formal species by Fabricius (1776). Later, Koefoed (1956) established a new subspecies (*E. spinosus eggvinii*) as distinct from *E. spinosus*, which then became recognized as two separate species formally by Ueno (1970) based on morphological differences. Recent research, however, using molecular tools showed that *E. spinosus* and *E. eggvinii* were a single, sexually dimorphic species (Byrkjedal *et al.* 2007). *Eumicrotremus*

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spinosus is a demersal fish widely distributed in the Canadian Arctic from Prince Patrick Island, the Grand Banks, Newfoundland to the west coast of Greenland, the Jan Mayen and Svalbard-Barents Sea region and the Kara Sea (Walter 1952; Roshchin 2006; Byrkjedal and Høines 2007; Wienerroither *et al.* 2011). It rarely occurs in very high numbers, but is regularly collected in trawl hauls (Wienerroither *et al.* 2011; pers. obs.), known to reach a maximum size of around 13 cm at which size they are a maximum of 3 years old (Wienerroither *et al.* 2011). The Atlantic spiny lumpsucker, despite being a demersal and slow moving fish (Wienerroither *et al.* 2011; pers. obs.), feeds on pelagic and hyperbenthic invertebrates such as krill and amphipods, but also polychaetes and larval stages of fish (Hutchings 2002; Roshchin 2006). Spawning has been reported to occur in August–September (Andriashev 1954; Wienerroither *et al.* 2011), although other reports indicate that it may be extended to January/February (Hutchings 2002). Furthermore, eggs have been observed attached to rocks (Wienerroither *et al.* 2011 and references therein). Otherwise, little knowledge exists concerning its life cycle history.

Herein, we report on the examination of a trawl by-catch from a high Arctic location within the archipelago of Svalbard. During a survey of polar cod in the Hinlopen Strait, an unusually large amount of Atlantic spiny lumpsuckers were collected, which were dissected and analysed for gonadosomatic index (GSI), hepatosomatic index (HSI), sex ratio and stomach content. The results not only provide new and basic knowledge of the life history and feeding behaviour of the Atlantic spiny lumpsucker, but also indirectly add important knowledge towards our understanding of deep migrating zooplankton layers in the Arctic marine ecosystem.

Material and methods

During a cruise with R/V *Helmer Hanssen* north of Svalbard in September 2012, 140 specimens of *Eumicrotremus spinosus* were collected at 215 m depth by bottom trawl in Hinlopen (79°32.70N, 18°48.52E). Temperature and depth profiles were measured with a Sea-Bird SBE9 CTD-rosette system. Bottom temperature in the area was 3.2°C and the surface temperature was 2.6°C. Temperature in the entire water column did not drop below 2.5°C, whereas the salinity varied between 34.1 PSU at the surface to 34.8 PSU near the bottom.

All 140 individuals were sexed. In addition, total length (acc. 0.1 cm), total body wet weight and somatic weight (acc. 0.1 g), and weights of the gonads and liver (acc. 0.01 g) were recorded for 26 individuals. Stomachs were dissected out and kept in 70% ethanol for determination of fullness and content analysis.

The gonadosomatic index (GSI) and the hepatosomatic index (HSI) were determined for 26 individuals according to the equations: $GSI = 100 \times (\text{gonad weight}/SW)$ and $HSI = 100 \times (\text{liver weight}/SW)$ in which SW is the somatic weight.

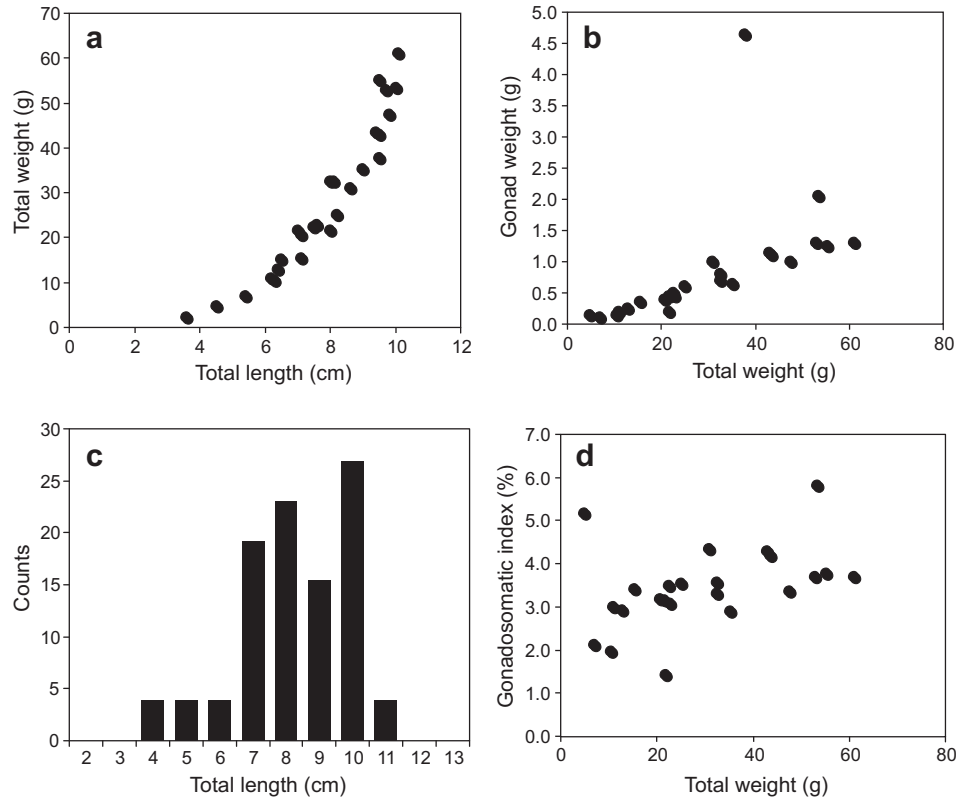


Fig. 1. Length, weight and gonad size of *Eumicrotremus spinosus*. **a**, total weight vs total length; **b**, gonad weight vs total weight of the fish; **c**, size distribution (frequency of occurrence) of all the 140 specimens; **d**, GSI vs total weight with one female excluded (seen as an outlier in section b of this figure).

Results and discussion

Life history.— The 140 individual lumpsuckers showed a size range between 3.6 and 10.1 cm (Fig. 1a), which is within the size range of previous studies from the region (Wienerroither *et al.* 2011 – see also Fig. 1a for weight vs length of a subsample of 26 specimens). The sex ratio was strongly biased towards females, with 78% of all 140 examined specimens (109 females, 27 males and 4 immature specimens) being females that all carried well developed gonads with visible eggs. Byrkjedal *et al.* (2007) recently documented that males of this species had previously been identified as representing a separate species based on the difference in tubercles on the head. In our examination, we did not separate individuals morphologically based on this character, and have hence treated all our specimens as one species (*E. spinosus*). A skewed sex ratio was also reported by Hutchings (2002) on fish caught in the Southern Gulf of St. Lawrence in September 2001 (73 females for 3 males) and in September 2000 (25 females for 10 males) as well as by

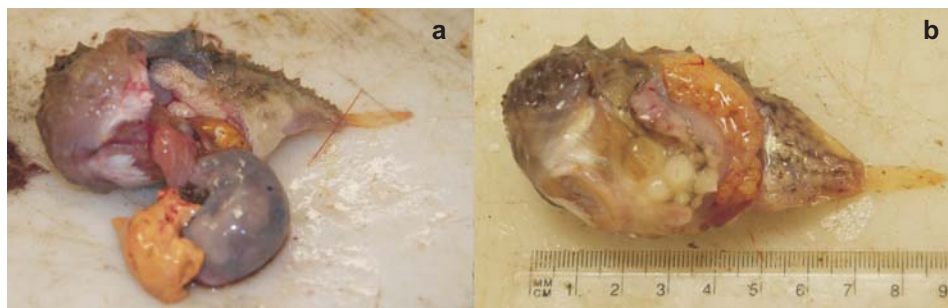


Fig. 2. Pictures of two female Atlantic spiny lumpsuckers; **a**, white eggs at an early developmental stage visible dorsally within the abdomen; **b**, ripe females with large yellow colored eggs. Photo: Andreas Rinvoll.

Roshchin (2006) in the waters of western Spitsbergen (Barents Sea) in June 2001 (35 females for 2 males). Sexual dimorphism is found in other cyclopteridae species (Arita 1969; Antonenko *et al.* 2009), but unfortunately the sex ratio against size was not noted in the present study and we cannot say whether there is a gender specific difference in size. These repeated reports on sex ratios skewed towards females may indicate a so far undocumented gender-specific reproductive strategy within this species, and should in future be highlighted as an important aspect in order to better understand its ecological adaptations towards the high Arctic marine habitat.

The HSI of the 26 randomly sampled individuals ranged between 3.7 to 14.8 (average 9.2 ± 2.8) and the GSI ranged from 1.4 to 4.8 except for one female with a GSI of 20.0% (average 4.1 ± 3.5) (Fig. 1c). All females carried eggs that were clearly visible, but most specimens were at an early stage of development compared to the most developed female with a GSI of 20% and conspicuously larger eggs than any of the other females (Fig. 2). Even specimens of only 4 cm length showed a GSI of 5% with visible eggs in their gonads, suggesting that *E. spinosus* becomes sexually mature at a very early age. This is in line with the very weak positive correlation (linear regression, $R^2 = 0.31$) between total weight and GSI (Fig. 1d), indicating an equal gonad development between each size class. The total life span of *E. spinosus* has previously been reported to be up to only three years (Wienerroither *et al.* 2011), which together with the herein reported observations provide at least circumstantial evidence of a relatively short, but iteroparous lifecycle for the females. Furthermore, the one female with GSI of 20% (Fig. 1b) suggests that the majority of females most likely were in an early gonad maturation phase. Previously, the Atlantic spiny lumpsucker has been reported to be an autumn-spawner with eggs that hatch in early spring (Andriashev 1954; Wienerroither *et al.* 2011). Based on our data, however, the Hinlopen specimens rather seem to reproduce in winter, with a build up of gonads during autumn. A review of the 112 fish species that occur in the Barents Sea and Svalbard region (Fig. 3,

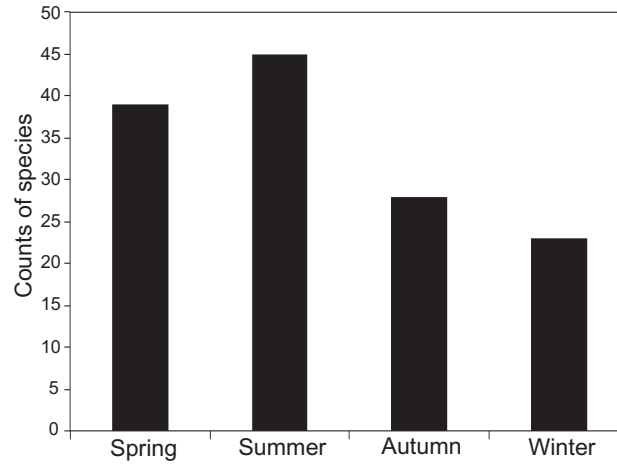


Fig. 3. Spawning period of fishes occurring in the Barents Sea based on data published by Wienerroither *et al.* 2011. Spring (March–May), Summer (June–August), Autumn (September–November), Winter (December–February). A total of 112 fish species occurring in the Barents Sea, of which no information on spawning period were available for 25. More than 50% of the taxa were listed as spawning in more than one season. Numbers inserted are the total count of species known to spawn within each season.

based upon information provided in Wienerroither *et al.* 2011) document not only that there is a relatively high proportion of the species that do in fact reproduce during winter, but also that the majority of species seem to have a breeding season that is flexible (*i.e.* reported spawning in more than one season). The Atlantic spiny lumpsucker falls, based upon existing data, well within this category of species with a flexible reproductive period. However, and possibly more importantly, the Arctic winter and polar night is emerging as a key period during which many reproductive and other ecological important processes occur (*e.g.* Berge *et al.* 2009, 2012). Kaartvedt (2008) hypothesized that the absence of large mesopelagic fish in the high Arctic is due to the light climate during the polar night that effectively prevents active predation. We, however, hypothesize that the ability to reproduce, rather than inability to feed during the polar night is a key adaptation that allow only a few species to colonize the Arctic Ocean and adjacent shelf seas. Hence, that there is a higher percentage of capital vs income breeders (Varpe 2012) among high Arctic fish species.

Feeding behavior. — *Eumicrotremus spinosus* has previously been reported to feed on hyperiid and gammarid amphipods (Węśławski and Kuliński 1989) in addition to a wide range of other taxa. Based upon our sample, *E. spinosus* appears to be a specialist predator on the Arctic pelagic amphipod *Themisto libellula*. Of all the 25 examined specimens (one stomach lost and excluded), 17 had full stomachs, 5 and 1 had 75% and 50% stomach fullness, respectively, while 2 had empty stomachs. *Themisto libellula* was the only prey item in 19 individuals and constituted a

Table 1

Relative amounts (%) of prey items of the 25 examined specimens (one stomach lost and excluded from the table).

number of fishes	<i>Themisto libellula</i>	gammarid amphipods	chaetognaths
20	100		
2	90–95		5–10
2	75–80	20–25	

minimum of 75% of all stomachs that contained food items (Table 1). Two specimens had a low proportion of chaetognaths, whereas yet another two had a few of hyperbenthic oedicerotid amphipods in their stomach. In contrast, *T. libellula* was not recorded in any abundance above 0.1 ind m⁻³ in any part of the water column using standard zooplankton nets (WP2 and WP3 – data not presented). This thus raises the question as to how a lumpsucker fish, often observed by SCUBA divers to be readily caught by hand and which do not appear to be capable of swimming away when approached (pers. obs.), are able to selectively feed on a strictly pelagic organism known to perform large diel migrations and with a measured swimming speed of up to 30 cm s⁻¹ (measurements of *T. japonica*, see Hiroki 1988). It has previously been reported mass mortalities of *T. libellula* along the shores of Spitsbergen (Eiane and Daase 2002), which could theoretically be an explanation for the high occurrence of *T. libellula*, which all seem to be in the same level of decomposition, from stomachs from *E. spinosus*. In order to rule this out as a possibility, stomachs of additional samples of *E. spinosus* collected in the same area three weeks later were examined. This survey showed the same results (unpublished), and is as such a strong indication that *E. spinosus* is actively feeding on living *T. libellula*.

Ecological implications and DVM of zooplankton. — Diel vertical migration (DVM) of zooplankton is a characteristic feature of all the world's oceans and lakes (Hays 2003), and has been documented to be an important process within the Arctic across all seasons of the year (Cottier *et al.* 2006; Berge *et al.* 2009; Wallace *et al.* 2010). Traditionally, DVM is considered to be triggered and modified by the relative changes in illumination, with the greatest relative rates of change in the light-level occurring during the transition from day to night and vice versa, acting as a cue for animals to migrate between surface and bottom layers (Ringelberg 1995). Such migration of animals to the surface layer at night allows zooplankton to feed at the food-rich surface waters while being invisible to visual predators (predator-avoidance hypothesis, Zaret and Suffern 1976) whereas during daytime seeking refuge in the deeper and thus less illuminated depths (Hays 2003). So far, most work within the Arctic has been conducted using acoustic instruments that has documented a pattern (*e.g.* Cottier *et al.* 2006; Berge *et al.* 2009), while other studies have used either standard zooplankton net samples (Błachowiak-Samołyk *et al.* 2006) or moored sediment traps (see Kraft *et al.* 2012 for an example of deep

T. libellula migrations) to identify which species are performing the migrations. However, both techniques generally fail to sample adequately in layers very close to the bottom, due to acoustic reflections from the sea floor and the general design of zooplankton nets, respectively (but see Hirche *et al.* 2006). The herein documented feeding behaviour of *E. spinosus* suggests that more emphasis should be placed at examining the aggregation of pelagic organisms in layers close to the bottom, simply due to the fact of the very high frequency of occurrence of *T. libellula* from stomachs of *E. spinosus*. Also, most of the *T. libellula* collected from the stomach analyses were in a relatively similar state of decomposition, indicating that most had been eaten at approximately the same time. Both of these facts (high frequency of occurrence in stomachs while at the same time low abundance from net samples as well as comparable state of decomposition) are indications that *T. libellula* do aggregate in very high densities very close to the bottom (see also Vinogradov 1999) during daytime. Also, hyperbenthic communities *i.e.* organisms living in the bottom meter(s) of the water column, are generally a poorly studied part of the marine Arctic food web, despite the fact that the group includes both overwintering copepods and a variety of other taxa collected in both benthic and pelagic sampling (chaetognaths, mysids, amphipod crustaceans, krill, and demersal fishes: Hirche *et al.* 2006). Densities of hyperbenthos are poorly known, but these organisms feed on surface sediments or benthic fauna, have large lipid stores (*e.g.* Connelly *et al.* 2012), and are often abundant in diets of fish and mammals (*e.g.* Grønvik and Klemetsen 1987 and data reported herein). Hence, we argue that our data, although limited and inconclusive, is an evidence of the importance of a hitherto neglected part of the fauna – pelagic organisms that effectively become hyperbenthic when performing deep diel migrations during daytime.

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