Available online at www.sciencedirect.com

ScienceDirect

Polar Science 5 (2011) 383–389

http://ees.elsevier.com/polar/

Survey of larval *Euphausia superba* lipid content along the western Antarctic Peninsula during late autumn 2006

Jennifer Putland*, Tracey Sutton

Harbor Branch Oceanographic Institution, Highway U.S. 1 North, Fort Pierce, FL 34946, USA

Received 3 March 2010; revised 15 January 2011; accepted 17 January 2011
Available online 2 February 2011

Abstract

A survey of larval *Euphausia superba* (furcilia stages four and six) was conducted in waters along the western Antarctic Peninsula during late autumn (May and June 2006). Larvae were collected from stations in four regions to estimate dry weight and lipid content. There were no statistically significant differences in the dry weight or lipid content among the regions sampled. The overall average (±S.D.) dry weight was 1.51 ± 0.32 mg indiv.$^{-1}$ and 0.85 ± 0.12 mg indiv.$^{-1}$ for F6 and F4 larvae, respectively. The average (±S.D.) lipid content was 21.6 ± 9.6 %DW and 27.9 ± 13.7 %DW for F6 and F4 larvae, respectively.

Keywords: Larvae; Krill; Heterotrophic; Recruitment

1. Introduction

Antarctic krill (*Euphausia superba*) is an extremely abundant euphausid and a keystone species in the Antarctic food web (Ross and Quetin, 1991). Most of the Antarctic krill stock occurs in the Southwest Atlantic sector of the Southern Ocean and in this region krill stocks have declined significantly over the last thirty years (Atkinson et al., 2004, 2008). Krill population size is partly a function of recruitment (Loeb et al., 1997; Siegel, 2005 & references therein). Krill recruitment, in turn, is a function of reproductive output and larval survival (Ross and Quetin, 1991; Siegel and Loeb, 1995; Quetin et al., 2007). Models that combine the physical oceanography of the Southwest Atlantic sector of the Southern Ocean and the life cycle of *E. superba* suggest that krill recruits in the region are, in part, transported in ocean currents from waters adjacent to the western Antarctic Peninsula (wAP) (Hofmann et al., 1998; Atkinson et al., 2001; Siegel, 2005; Fach and Klink, 2006).

The Antarctic Peninsula has experienced significant atmospheric warming since 1950 and is one of the fastest warming places on the planet (Vaughan et al., 2003; Ducklow et al., 2007). This warming has been accompanied by glacier melting on the Antarctic Peninsula (Cook et al., 2005; Clarke et al., 2007). Adjacent to the wAP, surface waters have warmed (Meredith and King, 2005; Ducklow et al., 2007) and sea-ice has been reduced in spatial extent (Clarke et al., 2007; Ducklow et al., 2007; Moline et al., 2008) and duration (Parkinson, 2002; Stammerjohn et al., 2008). Several of the mechanisms proposed to explain the reduced krill

---

* Corresponding author. Present address: 424 Goward Road, Victoria, BC V9E 2J5, Canada.

E-mail addresses: j.putland@alumni.ubc.ca, shibuya@nipr.ac.jp (J. Putland).

1873-9652/$ - see front matter © 2011 Elsevier B.V. and NIPR. All rights reserved.
doi:10.1016/j.polar.2011.01.001

population size pertain to how the warming and associated changes along the wAP can lead to reduced reproductive output and/or larval survival. For example, during summer in nearshore waters of the wAP, glacial meltwater can lead to a phytoplankton community dominated by cryptophytes, rather than diatoms (Dierssen et al., 2002; Moline et al., 2004). Increased dominance of cryptophytes may reduce reproductive output as adult krill reduce grazing when the phytoplankton assemblage is dominated by cryptophytes (Haberman et al., 2003). Likewise, the growth and survival of larval krill may be reduced by a phytoplankton community dominated by cryptophytes (Ross et al., 1988, 2000). Reductions in the spatial extent of sea-ice and delays in the formation and advance of sea-ice can lead to a reduction in the quantity of sea-ice microbiota (Nicol, 2006; Quetin et al., 2007; Fritsen et al., 2008). Since larval krill survive the winter, in part, by feeding on sea-ice microbiota (Daly, 1990; Ross and Quetin, 1991; Frazer et al., 2002), such a reduction in sea-ice microbiota may reduce larval survival through food limitation (Quetin et al., 2007).

Recruitment may also be reduced if larvae do not survive the autumn to winter transition. During this time phytoplankton biomass in the water column is typically very low. Larvae might survive this period by primarily utilizing their protein and lipid reserves until sea-ice forms and they can feed on sea-ice microbiota. Alternatively, larvae might survive this period by consuming heterotrophs (Meyer et al., 2002, 2009; Wickham and Berninger, 2007) and utilizing their reserves when there are periods of starvation (Meyer and Oettl, 2005). In both cases, the reserves of larval krill are important for larvae to survive the autumn to winter transition. How long larval krill can survive on their reserves is determined by their time to the point-of-no-return (PNR_{time}). The PNR_{time} is the time a larva has until it must find food or die. While larvae do not necessarily die at the PNR_{time}, once the PNR_{time} has passed they will eventually die even if they acquire food (Ross and Quetin, 1989). If larvae survive this period by primarily utilizing their protein and lipid reserves, then their PNR_{time} must be as long or longer than the time to sea-ice formation and advance (when sea-ice microbiota becomes available). Alternatively, if larvae survive this period by consuming heterotrophs and utilizing their reserves when there are periods of starvation, then their PNR_{time} must be as long or longer than the periods of starvation that the larvae may experience. In either case, a PNR_{time} that is shorter than the period of starvation experienced will likely lead to a reduction in recruitment.

E. superba catabolise lipid reserves preferentially to protein reserves (Ross and Quetin, 1989; Meyer and Oettl, 2005). Since there are relatively few published data on the lipid content of larval *E. superba* during late summer/fall (Table 1), the present study surveyed larval krill lipid content along the wAP during late autumn 2006. Lipid content reflects the integration of the environment experienced by the larvae over a period of weeks prior to collection (Daly, 2004). Gerlache Strait and Marguerite Bay may support higher lipid storage in larval krill. Spring and summer chlorophyll concentration is highly variable along the wAP; however, concentrations can peak in the vicinity of Gerlache Strait (Huntley and Brinton, 1991) and Marguerite Bay (Marrari et al., 2008; Smith et al., 2008). Previous research during summer indicates that many larval krill parameters (e.g., ingestion rate, length, weight, growth) are positively correlated with phytoplankton concentration (Huntley and Brinton, 1991; Pakhomov et al., 2004). Moreover, the highest larval dry weights appear to occur in Gerlache Strait and Marguerite Bay during summer (Huntley and Brinton, 1991; Meyer et al., 2003; Daly, 2004) suggesting that these locations provide a favorable environment for larval krill. The present study tests the hypothesis that larvae from Gerlache Strait and

Table 1
Literature data of dry weight (DW, mg indiv.$^{-1}$) and percent lipid content (Lip., %DW) for *Euphausia superba* furciliae that were freshly collected during late summer or autumn. dnr – did not report.

	F1-4[a]	F2[b]	F3[c]	F3[d]	F4[e]	F4[f]	F4[g]	F6[f]	F4-6[h]
DW	0.85	0.51	0.34–0.40	0.47	0.6	0.8–1.2	0.32–0.65	2.0–2.3	dnr
Lip.	10–30	6–22	11–25	14	13	dnr	dnr	dnr	20

[a] Hagen et al. (2001), Apr.–May, Southeastern Weddell Sea and Lazarev Sea.
[b] Meyer et al. (2003), Feb.–Mar., Rothera, Marguerite Bay.
[c] Meyer et al. (2002), Apr., Lazarev Sea.
[d] Stübing et al. (2003), Apr., Lazarev Sea.
[e] Meyer and Oettl (2005), Apr.–May, Bellingshausen Sea.
[f] Daly (2004), Apr.–Jun., Marguerite Bay.
[g] Pakhomov et al. (2004), Apr.–May, Bellingshausen Sea.
[h] Stübing et al. (2003), Apr.–May, Bellingshausen Sea.