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<https://doi.org/10.15760/etd.5572>

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AN ABSTRACT OF THE THESIS OF David Carl Rostal for the Master of Science in Biology presented March 14, 1986.

Title: The Effect of Salinity on Habitat Selection of Two Oregon Chiton Species (Katharina tunicata and Mopalia hindsii).

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

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Leonard Simpson, Chairman

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David T. Clark

Adult specimens of Katharina tunicata (mean weight = 10.23 grams) and Mopalia hindsii (mean weight = 10.90 grams) were tested for osmotic stress tolerance and oxygen consumption rates in a series of salinities (120%, 100%, 80%, 60%, and 40% seawater) at 11°C and 16L:8D photoperiod. K. tunicata and M. hindsii displayed similar trends in percent body weight variation and volume regulatory responses to osmotic stress. However, K. tunicata experienced a significantly higher percent body weight increase than did M. hindsii in response to hypo-osmotic conditions (80%, 60%, and 40% seawater). The mean rates of oxygen

consumption per salinity for the two species were not significantly different. Both species, however, showed reduced oxygen consumption rates and significantly increased weight gain in 40% seawater. SEM comparisons of radulae, ctenidia, and shape of the pallial groove revealed no significant differences between the species relevant to differences observed in habitat selection.

Salinity was measured bimonthly at the two study sites (K. tunicata - Indian Beach, open coast; M. hindsii - Tillamook Bay, brackish) during low tide from January 1985 to June 1985. Salinity measurements revealed a difference in mean salinity between study sites of 12% seawater.

Dominant macroalgal species were identified for the two study sites. Variation in dominant macroalgal species between study sites reflected published dietary preferences; K. tunicata feeds on Hedophyllum sessile, while M. hindsii feeds on Gigartina spp. and animal material. K. tunicata is generally restricted to open coast habitats and is considered stenohaline in nature, while M. hindsii is common to open coast as well as slightly brackish habitats and is considered euryhaline in nature.

The results of this study suggest that both species are osmoconformers with equivalent volume regulatory capabilities and are both euryhaline in nature. Other factors such as diet, larval settling responses, and interspecific competition may be involved in the difference observed in the habitat selection of K. tunicata and M. hindsii. Salinity appears not to be a major influence on habitat selection by these chiton species.

THE EFFECT OF SALINITY ON HABITAT
SELECTION OF TWO OREGON CHITON SPECIES
(Katharina tunicata AND Mopalia hindsii)

by

DAVID CARL ROSTAL

A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE
in
BIOLOGY

Portland State University

1986

TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

The members of the Committee approve the thesis of David Carl
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ACKNOWLEDGMENTS

I would like to thank my advisor, Dr. Leonard Simpson, and members of my committee, Drs. Richard B. Forbes and David T. Clark, for their support and valuable criticism of my manuscript. My thanks are extended to Michael C. Webb and Dr. W. H. Fahrenbach of the Oregon Regional Primate Research Center (ORPRC) for their invaluable assistance and techniques with the scanning electron microscope. I would also like to thank Joel Ito, Katie Simon, and Harry J. Wohlsein of the ORPRC for their assistance with the graphic and photographic components of my thesis. My thanks to Gerald M. Bell of the Department of Environmental Quality for his technical assistance and availability of the salinity meter. I would like to thank Alfred B. Lord, graduate student, for his assistance and support with data collection in the field. Finally, I would like to acknowledge my mother, Nita D. Rostal, for her encouragement and support of my graduate studies and research.

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CHAPTER I

INTRODUCTION

The effect of salinity on the physiology and ecology of marine molluscs has received limited attention. Prosser (1973) stated that marine molluscs are osmoconformers with varying degrees of stenohalinity. However, more recent evidence suggests that many marine molluscs (Littorina neritoides, Collisella digitalis, Acmaea scutum, Modiolus spp., and Mopalia muscosa) possess mechanisms for active volume regulation and are euryhaline in nature (Burton, 1983).

Among the marine molluscs, the Class Polyplacophora is comprised of only one group of animals, the chitons. Chitons are characterized as a morphologically uniform group and are strictly marine. However, chitons display distinct variations in distribution, microhabitat, diet preferences, and behavior. Chitons occur along rocky shores predominantly in the intertidal zones in all seas and latitudes (Hyman, 1967). Andrus and Legard (1976) compared the habitats of 12 chiton species along the California coast and concluded that surf strength, light exposure, substrate composition, moisture, and biological associates were all important in determining habitat selection.

The diet and feeding habits of many chiton species have been documented. Certain species are reported to display specific preference; e.g., Katharina tunicata feeds on Hedophyllum sessile and diatoms (Dayton, 1975; Himmelman, 1978), Tonicella lineata feeds on

crustose coralline algae (Steneck and Watling, 1982), and Placiphorella velata is predatory on amphipods (McLean, 1962). Other species are reported as indiscriminate or nonselective grazers, e.g., Mopalia spp. feed on Gigartina spp., Endocladia spp., Gelidium sp., (Dayton, 1975; Steneck and Watling, 1982) as well as animal material (Morris et al., 1980), Cyanoplax hartwegii feeds on Pelvetia sp., Hildenbrandia sp., Petrocelis sp., Endocladia sp., and Cladophora (Robb, 1976; Steneck and Watling, 1982), and Nuttallina californica feeds on bluegreen algae and diatoms (Nishi, 1976).

The activity patterns and behavior of chitons has been related to their ecology. Chelazzi et al. (1983) reported that variation in movement patterns of two sympatric species (Acanthopleura brevispinosa and A. gemmata) minimizes zonal overlap and reduces interspecific competition. Gómez (1976) observed a commensal association between two sympatric species (Nuttallina californica and Cyanoplax hartwegii) along the California coast.

The physiology of several chiton species has been investigated. Boyle (1969) studied the survival of Sypharochiton pelliserpentis exposed to osmotic stress conditions and concluded this species could osmoconform to salinities ranging from 50% to 150% seawater. McGill (1976) reported that Cyanoplax hartwegii is an osmoconformer over a salinity range of 75% to 125% seawater and capable of volume regulation. Simonsen (1976) found that environmental acclimation to varying salinities affected osmotic stress tolerances in Nuttallina californica. Stickle and Denoux (1976) reported that hemolymph osmotic concentration of Katharina tunicata fluctuated with tidal fluctuation in osmotic

concentration but did not vary during exposure to air. Stickle and Ahokas (1975) postulated that Mopalia muscosa is less susceptible to osmotic stress than K. tunicata. Lebsack (1976) determined that temperature and variation in salinity from normal seawater affect oxygen consumption rates in Mopalia lignosa.

In this study, the effects of salinity on habitat selection was investigated in two Oregon chiton species, Katharina tunicata and Mopalia hindsii. K. tunicata is generally restricted to open coast habitats and is considered stenohaline in nature, while M. hindsii is common to open coast as well as slightly brackish habitats and is considered euryhaline in nature. The objectives of this study were to compare these two species with regard to their osmotic stress tolerance; their volume regulatory capabilities; the influence of salinity on oxygen consumption rates; variations in the morphology of their radulae, ctenidia, and shape of the pallial groove; and to relate physiological and morphological adaptations of K. tunicata and M. hindsii to difference in their ecology and habitat selection.

CHAPTER II

METHODS AND TECHNIQUES

Subjects

Katharina tunicata range in body length to 12 cm, are elongate to oval in shape, and have valves deeply embedded in the girdle. K. tunicata possess a thick, leathery girdle which is shiny and black. They are common in the middle and low intertidal zones clinging to the sides and upper surfaces of rocks along the unprotected outer coast where they are exposed to strong wave action and direct sunlight (Fig. 1A; Morris et al., 1980).

Mopalia hindsii range in body length to 10 cm, are oval and depressed in shape, and have well exposed valves. M. hindsii possess a "mossy" girdle which is dull and brown. They are common under rocks, on inward-sloping rock faces, or in crevices in the middle and low intertidal zones on the outer coast where surf is strong, as well as on wharf pilings in bays and even in slightly brackish waters (Fig. 1B; Morris et al., 1980).

Figure 1. Adult specimens of Katharina tunicata (A) and Mopalia hindsii (B).

Study Sites

An open coast and a brackish water study site were chosen for K. tunicata (Indian Beach, Ecola State Park) and M. hindsii (Garibaldi, Tillamook Bay) respectively. Site selection was based on salinity and temperature characteristics as well as common intertidal indicator species.

Indian Beach, Ecola State Park, Clatsop County, Oregon (45°55'N latitude) has a large rock and boulder outcropping at the south end of the beach where wave action is strong (Fig. 2A). K. tunicata is common in this location with M. hindsii and Tonicella lineata also present. Other common open coast organisms present are Pisaster ochraceous, Mytilus californianus, Hemigrapsus nudus, and Pollicipes polymerus. Mean annual salinity is 29.06 ppt (85% seawater) and mean annual temperature is 12.4°C (Fig. 3, Seaside Aquarium Data; Bourke and Glenne, 1971).

Garibaldi, Tillamook Bay, Tillamook County, Oregon (45°34'N latitude) has a shale outcropping with small to large loose rocks at the north end of the bay with weak wave action (Fig. 2B). M. hindsii and M. muscosa are found under rocks and in crevices. Other common brackish water organisms present are Hemigrapsus oregonensis, Mytilus edulis, Pagurus spp., and Nucella emarginata. Mean annual salinity is 25.47 ppt (75% seawater) and mean annual temperature is 10.9°C (Fig. 3, raw data from the State of Oregon, Department of Environmental Quality).

Figure 2. Indian Beach, Ecola State Park study site (A) and Garibaldi, Tillamook Bay study site (B) during low tide.

Figure 3. Mean monthly salinity (A, ppt) and mean monthly water temperature (B, °C) for Indian Beach and Garibaldi study sites.

Osmotic Stress Tests

Adult K. tunicata (mean weight = 10.23 grams) and M. hindsii (mean weight = 10.90 grams) were collected and acclimated to 34 ppt synthetic seawater (100% SW, Instant Ocean Synthetic Sea Salts, Aquarium Systems, Inc.) at 11°C and 16L:8D photoperiod for two weeks prior to testing. Eight animals of each species were subjected to a test salinity (120%, 100%, 80%, 60%, and 40% SW) for 36 hours in osmotic test apparatus (Fig. 4). Individual animals were held in separate chambers and monitored individually throughout the test. At time intervals of 0, 1, 2, 4, 6, 8, 12, 24, and 36 hours, animals were removed from chambers, blotted dry with absorbent towels, and then weighed using a Mettler PC 2200 scale. Animals were allowed 5 minutes to readhere in the chambers before being resubmerged in test salinity. Percent body weight changes due to osmotic stress gradient and volume regulation were calculated.

Oxygen Consumption Tests

Oxygen consumption rates for four animals of each species were measured using a modified Scholander's respirometer (Scholander, 1950). Animals were monitored in test salinities (120%, 100%, 80%, 60%, and 40% SW) for 3-4 hours at 11°C and 16L:8D photoperiod following 48 hours of acclimation to the test salinity (normally post-osmotic stress testing). Oxygen consumption rates ($\mu\text{l/g/hr}$) were calculated for each species per salinity.

Figure 4. Osmotic stress test apparatus used to measure osmotic stress tolerance and volume regulatory rates of adult specimens of *Katharina tunicata* and *Mopalia hindsii*. Specimens (8 per test) were held in individual chambers which allowed free movement and continuous circulation of seawater.

Morphological Comparisons

Radulae, ctenidia, and shape of the pallial groove were examined and compared using an AMR Model 1000 scanning electron microscope and an ISI-SS40 scanning electron microscope.

Specimens of K. tunicata and M. hindsii were anesthetized using an isotonic $MgCl_2$ solution (73 g/l DH_2O) for 1-2 hours. Desired structures were dissected and prepared. Radulae were cleaned and rinsed with cacodylate buffer (pH 7.4) in an ultrasonic cleaner and then allowed to air dry. Gill tissue and whole specimens were fixed in 6% glutaraldehyde at 4°C for one and four hours respectively (Bell et al., 1969). Specimens were then dehydrated through 25%, 50%, 70%, 95%, and two changes of 100% ethanol. Gill tissue and whole specimens were freeze-fractured in 100% ethanol using liquid nitrogen in order to expose lamellar structure and pallial groove organization respectively (Humphreys et al., 1974). Next, specimens were flushed with liquid freon (50% and 100%) and then dried using an Omar SPC - 900/EX Critical Point Dryer. Specimens were mounted on stubs and coated with 200 Å of gold using a Technics Sputter Coater.

Habitat Characteristics

Seawater samples were collected bimonthly at the two study sites during low tide from January 1985 to June 1985. Salinity (ppt) of seawater samples was determined using a YSI-33 Salinity-Conductivity-Temperature (S-C-T) Meter.

Dominant macroalgal species were collected from each study site and identified (Smith, 1969; Guberlet, 1956). Macroalgal species present were compared with published diet preferences of the chitons (Steneck and Watling, 1982; Morris et al., 1980).

Statistical Analysis

Significant differences in osmotic stress response between K. tunicata and M. hindsii were analyzed using a Multifactor Analysis of Variance (repeated measures; Winer, 1971). Significance level was $p < 0.05$.

Significant differences in oxygen consumption rates between K. tunicata and M. hindsii were analyzed using an Independent t-Test (Bruning and Kintz, 1977). Significant differences in oxygen consumption rates between salinities within each species were analyzed using an Analysis of Variance (completely randomized design; Bruning and Kintz, 1977). Significance level was $p < 0.05$.

CHAPTER III

RESULTS

Osmotic Stress Tests

K. tunicata and M. hindsii displayed similar trends in percent body weight (% BW) variation and volume regulatory responses to osmotic stress (Fig. 5). However, K. tunicata experienced a significantly higher percent body weight increase than did M. hindsii in response to hypo-osmotic conditions (80% SW, $df = 1,14$, $F = 6.13$, $p < 0.05$; 60% SW, $df = 1,14$, $F = 16.85$, $p < 0.005$; 40% SW, $df = 1,14$, $F = 17.89$, $p < 0.001$). Following maximum percent body weight variation, both K. tunicata and M. hindsii displayed similar volume regulatory rates. Maximum percent body weight variation was measured within 4 hours of exposure to 120%, 100%, 80%, and 60% seawater (Table I). However, maximum percent body weight variation in 40% seawater was not reached until 24 hours following exposure (K. tunicata = 57.91 ± 1.57 % BW, M. hindsii = 49.32 ± 1.86 % BW). Both species displayed reduced activity and adherence capabilities in 40% seawater compared with other salinities tested.

Figure 5. Mean percent body weight change (% BWΔ) and volume regulatory rates of adult specimens of *Katharina tunicata* and *Mopalia hindsii* in various test salinities over a 36 hour test period at 11°C and 16L:8D photoperiod.

TABLE I

MAXIMUM PERCENT WEIGHT CHANGE FOR TWO OREGON CHITON SPECIES
 (Katharina tunicata AND Mopalia hindsii)
 IN VARIOUS SALINITIES

% SW	<u>K. tunicata</u>	<u>M. hindsii</u>
120	-7.899 ± 0.181 (8)	-7.165 ± 0.248 (8)
100	2.276 ± 0.156 (8)	1.835 ± 0.325 (8)
80	11.456 ± 0.402 (8)	10.000 ± 0.527 (8)
60	31.423 ± 0.739 (8)	26.115 ± 0.907 (8)
40	57.906 ± 1.573 (8)	49.321 ± 1.864 (8)

Results are mean values ± SE (n).

Individuals tested in 40% seawater were held in test salinity for 5 days following standard test time to measure survival rates. Both species were able to volume regulate to pre-test range (K. tunicata - starting mean weight ± SE = 9.87 ± 0.92 grams, ending mean weight ± SE = 10.94 ± 0.90 grams; M. hindsii - starting mean weight ± SE = 10.03 ± 0.81 grams, ending mean weight ± SE = 10.12 ± 0.81 grams). All animals survived this period, however, K. tunicata were inactive and adhered poorly to the holding tank sides. When returned to 100% seawater, 50% of the K. tunicata specimens were unable to reacclimate and died, whereas 100% of the M. hindsii were able to reacclimate and survived. Results suggest that 40% seawater is below the ecological tolerance of both species, but M. hindsii appears to be more tolerant of the osmotic stress.

Oxygen Consumption Tests

Oxygen consumption rates per salinity were not significantly different between K. tunicata and M. hindsii (Table II). K. tunicata and M. hindsii displayed similar trends in response to salinity variation (Fig. 6). The mean rate of oxygen consumption by K. tunicata was found to decrease significantly with the decrease in salinity to 40% seawater ($df = 4,14$, $F = 3.24$, $p < 0.05$). The mean rate of oxygen consumption by M. hindsii was also found to decrease similarly to K. tunicata in response to decrease in salinity to 40% seawater; however, the decrease observed for M. hindsii was not found to be significant ($df = 4,14$, $F = 0.88$, not sig.). The reduction in mean rates of oxygen consumption in 40% seawater by both K. tunicata and M. hindsii is similar to the trend in body weight variation and decrease in activity observed during osmotic stress tests.

TABLE II

OXYGEN CONSUMPTION RATES ($\mu\text{l/g/hr}$) FOR TWO OREGON CHITON SPECIES
(Katharina tunicata AND Mopalia hindsii)
IN VARIOUS SALINITIES

% SW	<u>K. tunicata</u>	<u>M. hindsii</u>
120	11.9 $\pm$ 2.2 (4)	10.6 $\pm$ 2.3 (4)
100	13.5 $\pm$ 1.3 (4)	12.7 $\pm$ 1.2 (3)
80	11.3 $\pm$ 0.6 (4)	11.7 $\pm$ 2.9 (4)
60	10.6 $\pm$ 1.7 (4)	12.4 $\pm$ 2.7 (4)
40	5.7 $\pm$ 0.9 (3)	7.6 $\pm$ 1.0 (4)

Results are mean $\pm$ SE (n)

Figure 6. Mean oxygen consumption rates (VO_2) of adult specimens of *Katharina tunicata* and *Mopalia hindsii* in various test salinities at 11°C and 16L:8D photoperiod. Results are mean values $\pm$ SE.

Morphological Comparisons

Comparisons of radular morphology of K. tunicata and M. hindsii revealed only minor variations. Radulae of both species are comprised of seventeen teeth per row with major adaptation of the l_2 and l_5 teeth (Grassé, 1960) for grazing purposes (Fig. 7). The grazing teeth (l_2 and l_5) of both species are similar in structure (Fig. 8). The primary difference observed between K. tunicata and M. hindsii is a variation in the anterior end of the median (m) teeth (Fig. 9).

Differences in ctenidial morphology between K. tunicata and M. hindsii are related to differences in the shape of the pallial grooves of the two species. Ctenidia of K. tunicata are rounded and blunt while those of M. hindsii are more pointed and laterally flattened (Fig. 10). Ctenidial surfaces revealed no major interspecific differences in organization; both species possess a prominent lateral bands of cilia (Fig. 11; Hyman, 1967). The ctenidial lamellae of the two species have similar organization of vascular bed and respiratory epithelium comprised of a simple cuboidal to columnar epithelium (Fig. 12; Hyman, 1967)

The pallial groove of K. tunicata differs from M. hindsii in two aspects. The pallial groove of K. tunicata is taller with ctenidia suspended perpendicularly to the substrate. The pallial groove of M. hindsii is shallower and broader with gill ctenidia curved and suspended at an angle to the substrate (Figs. 13 and 14).

Figure 7. Radulae of *Katharina tunicata* (A, mag. = 78X) and *Mopalia hindsii* (B, mag. = 53X) revealing general organization plus grazing teeth (l₂ and l₅) and median teeth (m).

Figure 8. Grazing teeth (2nd lateral - l_2 , and 5th lateral - l_5) from radulae of Katharina tunicata (A, mag. = 130X) and Mopalia hindsii (B, mag. = 130X).

Figure 9. Median teeth (m) from radulae of Katharina tunicata (A, mag. = 322X) and Mopalia hindsii (B, mag. = 308X) revealing the variation in the anterior tip.

Figure 10. Ctenidia (ct) from *Katharina tunicata* (A, mag. = 113X) and *Mopalia hindsii* (B, mag. = 113X) revealing variation in shape.

Figure 11. Surfaces of ctenidia from Katharina tunicata (A, mag. = 1100X) and Mopalia hindsii (B, mag. = 1125X) revealing ciliation (ci) and respiratory surface (rs).

Figure 12. Lamellar structure of ctenidia from *Katharina tunicata* (A, mag. = 1400X) and *Mopalia hindsii* (B, mag. = 1700X) revealing the hemocoel (hc), respiratory epithelium (re), and interlamellar water channel (wc).

Figure 13. Pallial groove and ctenidia (ventral view) of *Katharina tunicata* (A, mag. = 53X) and *Mopalia hindsii* (B, mag. = 28X) revealing variation in shape of groove and orientation of ctenidia (ventral surface of mantle - ma, ctenidia - ct, and foot - ft).

Figure 14. Pallial groove (X - section) and ctenidia of *Katharina tunicata* (A, mag. = 70X) and *Mopalia hindsii* (B, mag. = 70X) revealing variation in shape of pallial groove, mantle valve, and orientation of ctenidia (mantle - ma, mantle valve - v, ctenidia - ct, and pallial groove - pg).

Habitat Characteristics

Salinity measurements at low tide from January 1985 to June 1985 yielded a mean salinity of 25.63 ± 0.85 ppt (75% seawater) for the Indian Beach study site and a mean salinity of 21.04 ± 1.05 ppt (63% seawater) for the Garibaldi study site. During April 1985, there was an overlap in the salinities of the study sites. However, Garibaldi consistently reached lower extremes in salinity (February = 19.2 ppt, April = 16.7 ppt, and June = 15.5 ppt) than Indian Beach (April = 20.8 ppt; Fig. 15). Although mean salinities during the study were found to be lower than mean annual salinities for study sites (Indian Beach = 29.06 ppt, Garibaldi = 25.47 ppt), the variation in mean salinities between study sites during the study (4.59 ppt, 12% seawater) parallels the variation in mean annual salinities (3.59 ppt, 10% seawater). Measurements were taken primarily during the winter months when fresh-water runoff from coastal land is greatest.

Identification of dominant macroalgal species revealed variation between the Indian Beach site (six Rhodophyta, three Phaeophyta) and the Garibaldi site (four Rhodophyta, three Phaeophyta, and one Chlorophyta) in species present (Table III). Three macro-algal species (Laminaria setchellii, Fucus distichus, and Iridaea cordata) were common to both study sites. The coralline algae (crustose coralline alga and Bossiella orbigniana), Gymnogongrus linearis, Plocamium oregonum, Prionitis lanceolata, P. linearis, and Hedophyllum sessile were identified at the Indian Beach site only. Hedophyllum sessile is reported as a major dietary constituent of K. tunicata (Steneck and Watling, 1982). Gigartina exasperata, G. volans, Gracilaria verrucosa, Halosaccion

glandiforme, and Ulva taeniata are common to the Garibaldi site. Gigartina spp. as well as animal material are reported as common dietary constituents of Mopalía spp. (Steneck and Watling, 1982; Morris et al., 1980).

Figure 15. Bimonthly salinity measurements during low tide from January 1985 to June 1985 for Indian Beach and Garibaldi study sites.

TABLE III

DOMINANT MACROALGAL SPECIES OF INDIAN BEACH, ECOLA STATE PARK STUDY
SITE AND GARIBALDI, TILLAMOOK BAY STUDY SITE

Macroalgal Species	Indian Beach	Garibaldi
<u>Rhodophyta</u>		
Crustose Coralline Alga	****	
<u>Bossiella orbigniana</u>	****	
<u>Gigartina exasperata</u>		****
<u>Gigartina volans</u>		****
<u>Gracilaria verrucosa</u>		****
<u>Gymnogongrus linearis</u>	****	
<u>Iridaea cordata</u>	****	****
<u>Plocamium oregonum</u>	****	
<u>Prionitis lanceolata</u>	****	
<u>Prionitis linearis</u>	****	
<u>Phaeophyta</u>		
<u>Fucus distichus</u>	****	****
<u>Halosaccion glandiforme</u>		****
<u>Hedophyllum sessile</u>	****	
<u>Laminaria setchellii</u>	****	****
<u>Chlorophyta</u>		
<u>Ulva taeniata</u>		****

CHAPTER IV

DISCUSSION

Variation in habitat selection by marine chitons is thought to be influenced by salinity. However the influence of salinity on the physiology and ecology of chitons has received limited attention. Boyle (1969) reported that S. pelliserpentis is exposed to salinity fluctuations of 40% (14 ppt) to 130% (45 ppt) seawater for short periods of time. Stickle and Denoux (1976) observed that in many marine invertebrates, including K. tunicata, hemolymph osmoconcentrations fluctuate with tidal fluctuation but do not vary during exposure to air.

The influence of salinity on variation in habitat selection of K. tunicata and M. hindsii appears to be minimal. Although K. tunicata displayed significantly higher variation in percent body weight than did M. hindsii in response to hypotonic stress conditions (80%, 60%, and 40% SW), both species displayed similar rates of weight gain and volume regulation in all salinities tested. Both species, however, experienced drastically increased weight gain in response to 40% seawater compared with other salinities tested. The percent weight changes observed for both K. tunicata and M. hindsii in 60% to 120% seawater are similar to those reported by McGill (1976) for C. hartwegii in 75% to 125% seawater. Boyle (1969) tested the osmotic stress tolerance of S. pelliserpentis in 0% to 150% seawater and found that species tolerant of salinity ranging from 50% to 150% seawater.

However, the response of S. pelliserpentis to 50% seawater was similar to that observed for K. tunicata and M. hindsii in 40% seawater. The results support the hypothesis that K. tunicata and M. hindsii are osmoconformers with volume regulatory capacities and are similar in osmotic stress tolerance to S. pelliserpentis, C. hartwegii, and N. californica (Boyle, 1969; McGill, 1976; and Simonsen, 1976).

Lebsack (1976) reported that deviation in salinity from normal seawater results in a decrease in oxygen consumption rate by Mopalia lignosa, although the salinities Lebsack tested ranged only from 90% to 120% seawater. Oxygen consumption rates for K. tunicata were observed to decrease significantly in response to salinity variation from 100% seawater, while M. hindsii oxygen consumption rates did not. Both K. tunicata and M. hindsii, however, displayed equally reduced oxygen consumption rates in response to 40% seawater. This reduction in oxygen consumption in 40% seawater parallels the increased weight gain observed in the osmotic stress tolerance results.

Stickle and Ahokas (1975) suggested that Mopalia muscosa may be more resistant to osmotic stress than is K. tunicata because M. muscosa may be able to isolate its pallial groove and ctenidia from the external medium more effectively than can K. tunicata. M. muscosa and M. hindsii overlap in distribution and both are common in the Garibaldi study site. The two species are morphologically similar, differing primarily in the dorsal surface of the mantles. Comparison of the shape of the pallial groove, mantle valve size, and ventral surface of the mantles of K. tunicata and M. hindsii, however, suggested no significant variation between these two species in their ability to isolate the pallial groove

and ctenidia. The differences observed in the shape of the pallial groove and ctenidia reflect differences in general body morphology which correlate more directly with micro-habitat preferences than differences observed in habitat selection of these species.

The variation in mean salinity (4.59 ppt, 12% SW) observed between the Indian Beach and Garibaldi study sites from January 1985 to June 1985 is within the physiological tolerances of both K. tunicata and M. hindsii. The increase in body weights and decrease in oxygen consumption rates of K. tunicata and M. hindsii in 40% seawater dilution, and their reduced adherence capabilities suggests that this salinity is near or below the ecological tolerances of both species even though it is physiologically tolerable under laboratory conditions. Salinities below 40% seawater were not measured for either study site. Although K. tunicata is capable of tolerating 40% seawater for a limited period, the data suggest that M. hindsii may be more tolerant of this extreme dilution. Boyle (1969) reported that S. pelliserpentis could survive dilution to 50% seawater for at least 24 hours. Simonsen (1976) suggested that long term acclimation to variation in salinity may influence osmotic stress tolerance in N. californica. Thus, acclimation may account in part for the observed variation in osmotic tolerance to extreme dilution (40% SW) between K. tunicata and M. hindsii.

The diet preferences of K. tunicata and M. hindsii may influence the difference observed in habitat selection. Hedophyllum sessile, a major dietary constituent of K. tunicata, is restricted to open coast habitats such as the Indian Beach site (Himmelman, 1978; Steneck and Watling, 1982). Several Gigartina spp. plus animal material, major

dietary constituents of M. hindsii, are less restricted and are common at the Garibaldi site (Morris et al., 1980; Steneck and Watling, 1982). Comparison of radular morphology and structure of grazing teeth (1_2 and 1_5), however, revealed no clear difference between K. tunicata and M. hindsii related to adaptation to different diets. Radular morphology of both these species support the "multi-purpose tool" description of Steneck and Watling (1982).

Boyle (1969) suggested, "that microhabitat osmotic fluctuations are unlikely to limit the distribution of S. pelliserpentis", due to its euryhaline characteristics. The data support a similar conclusion for K. tunicata and M. hindsii in that both are euryhaline in character and display similar physiological capabilities.

Although salinity may not influence the difference in habitat selection observed between K. tunicata and M. hindsii, it still may influence habitat selection in two ways: 1) the tolerance to osmotic stress of larval stages may vary significantly; and 2) the influence of salinity on macroalgal species may affect the settling responses of veliger stage. Barnes and Gonor (1973) reported that T. lineata larvae display a selective settling response to crustose coralline algae, Lithothamnium and Lithophyllum spp.

In conclusion, these results suggest that other factors are involved in the difference in habitat selection between K. tunicata and M. hindsii, and that chitons display a high level of physiological plasticity.

Summary

1. Katharina tunicata and Mopalia hindsii are osmoconformers in salinities ranging from 40‰ (13.7 ppt) to 120‰ (41.0 ppt) seawater with equivalent volume regulatory capabilities.
2. Both species showed reduced oxygen consumption rates and significantly increased weight gain in 40‰ seawater.
3. SEM comparisons of radulae, ctenidia, and shape of the pallial groove revealed no significant differences between the species relevant to differences observed in habitat selection.
4. Variation in dominant macroalgal species between study sites reflected published dietary preferences; K. tunicata feeds on Hedophyllum sessile, while M. hindsii feeds on Gigartina spp. and animal material.
5. Salinity does not appear to be a major influence on habitat selection in chitons within the intertidal zone.

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