Université de Nantes

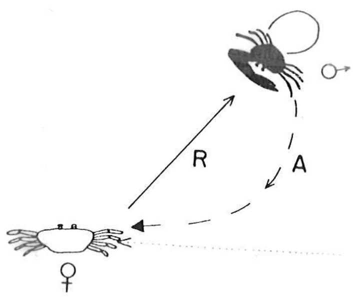
Faculté des Sciences

L3 SVT

BIOECOLOGIE

BIOECOLOGIE ANIMALE – PROF. P. BENINGER

Illustrations du cours



L3 STUE-SVT

BIOECOLOGIE

Cours P. Beninger

- Bioécologie –Définition
- Les grands groupes choisis et pourquoi

1. Les Mollusques
    - Rôles du mucus chez les Gastéropodes
    - Reproduction d'un Gastéropode d'intérêt médical ; perspectives pour la gestion de la population et l'aquaculture
    - Le cycle vital des Bivalves
    - Le développement des Bivalves et importance pour la biologie populationnelle et l'aquaculture
    - Les techniques d'élevage
    - La détermination de la condition physiologique

2. Les Arthropodes
    - Paramètres vitaux des jeunes stades d'un Chelicérate d'intérêt médical ; importance pour la gestion de la population
    - Les stades larvaires des Crustacés
    - Aquaculture des Crustacés
    - Les problèmes écologiques de l'aquaculture et solutions potentielles
    - La reproduction et conséquences pour la gestion des populations : l'exemple des Majidae

3. Les Echinodermes
    - Stades larvaires et ancêtre commun
    - Les Echinodermes d'intérêt économique : les Echinoïdes
    - Reproduction et aquaculture des Echinoïdes
    - Biologie larvaire : induction de la métamorphose
    - Ecologie de populations sauvages : paradigmes
    - Les Holothuries : reproduction, aquaculture et gestion des populations sauvages

Phylum Mollusca

Mono-, Poly-, Aplacophora

Gastropoda

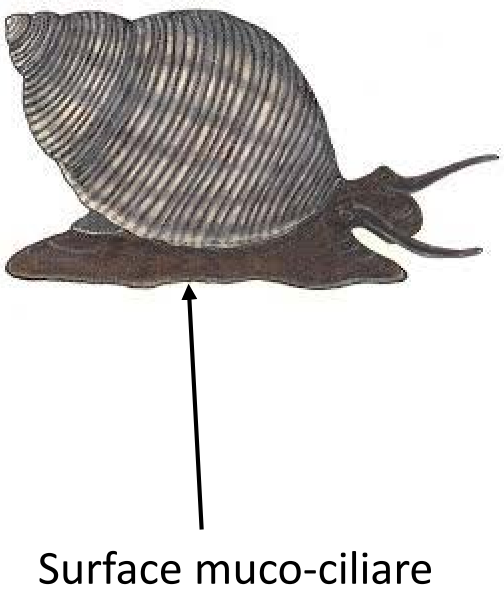
Bivalvia

Cephalopoda

Scaphopoda

Scaphopoda – importance culturelle

Gastropoda : ex. Fam. Littorinidae et Patellidae



Les pistes de mucus pédieux

Utilisation du mucus pédieux en cosmétique

Riche en acide hyaluronique, antioxydants;
Stimule collagénèse, retarde viellissement?

J. Exp. Mar. Biol. Ecol., 150 (1991) 91–105

JEMBE 01615

Energetics of mucus production in the common whelk *Buccinum undatum* L.

Ahmet E. Kideys and Richard G. Hartnoll

Port Erin Marine Laboratory, University of Liverpool, Isle of Man, UK

(Received 12 December 1990; revision received 28 February 1991; accepted 9 March 1991)

Abstract: Pedal and hypobranchial mucus production of the common whelk *Buccinum undatum* L. were measured at three different temperatures (8.2, 10.5 and 15 °C). Pedal mucus production at 8.2 °C was significantly lower from that at 10.5 °C, but similar to that at 15 °C. In contrast hypobranchial mucus production at 8.2 °C was significantly higher than that at 10.5 °C but again similar to that at 15 °C. At all temperatures whelks produced more hypobranchial than pedal mucus. Food consumption was measured, and from this it was determined that ≈27.5% of the total energy intake appeared as mucus production (pedal + hypobranchial). Other studies on gastropod mucus energetics are reviewed, and possible sources of error in the determination of mucus energetics are discussed.

Key words: *Buccinum*; Energetics; Gastropod; Mucus; Temperature

TABLE V

B. undatum: estimated percentage of total energy intake at 10.5 °C invested in mucus by various sizes (shell length 30–90 mm) of whelk. Based on equations for mucus production in Table II and for food consumption in Table IV.

Animal dry wt (g)	Mucus type		
	Hypobranchial	Pedal	Total
1	18.1	8.9	27.0
3	14.0	8.0	22.0
5	15.7	10.4	26.1
7	19.7	15.1	34.8
$\bar{x}$	16.9	10.6	27.5

The Veliger 29(1):31–37 (July 1, 1986)

THE VELIGER

Observations on the Mechanism of Detecting Mucous Trail Polarity in the Snail *Littorina irrorata*

by

D. STIRLING AND P. V. HAMILTON[1]

Department of Biology, University of West Florida, Pensacola, Florida 32514, U.S.A.

Abstract. Marsh periwinkles, *Littorina irrorata,* can detect the polarity of conspecific mucous trails for at least 60 min after they are deposited. Experiments indicate that trail polarity detection does not involve discriminating a longitudinal concentration macro-gradient of a volatile chemical substance using the paired cephalic tentacles. If only one cue provides trail polarity information, then a bilateral trail asymmetry, a topography-based physical map, and a reflected light pattern are probably not involved either. The possibility that trail polarity information is obtained from directional microstructures in gastropod mucous trails is discussed.

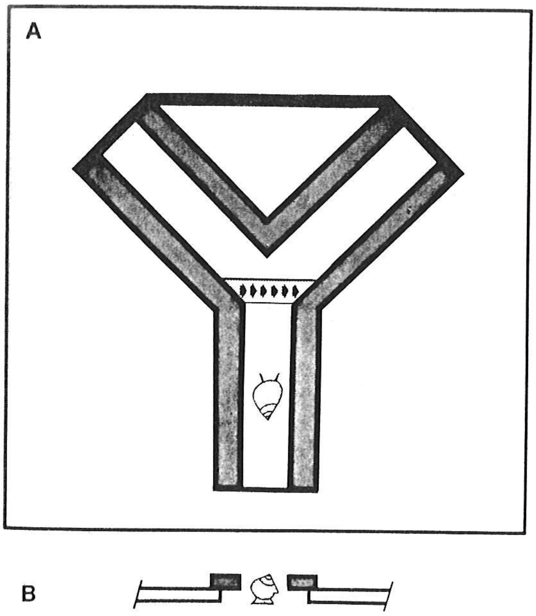


Figure 1

A. Top view of Y-maze used to study trail polarity detection. Three black paper targets (thickest lines) were 9 cm high. The maze was placed on the surface bearing the test mucous trail (stippled) so that the trail was positioned at the end of the approach path. The trail is drawn wider than normal. The arrows indicate the direction in which the trail-depositing snail was traveling. A mucous trail's width is normally about 50% of the depositing snail's shell width. A test snail is shown halfway along the approach path. B. Cross-sectional view of test snail on approach path showing overhangs (shaded). All tests with the maze were conducted in a special arena.

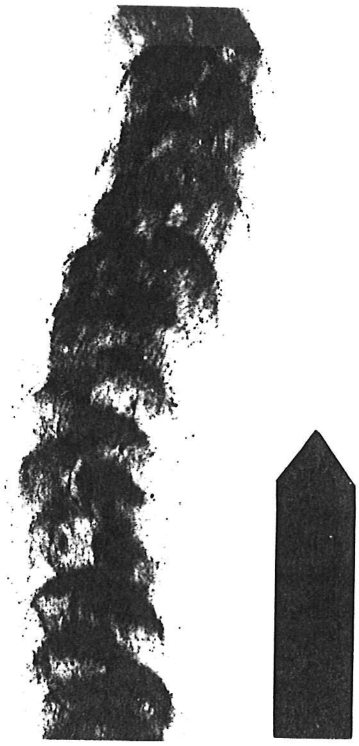


Figure 2

Stained mucous trail of *Littorina irrorata* showing chevron-shaped pattern of zones of high stain uptake. The 1-cm long arrow indicates the direction in which the trail-depositing snail was traveling.

J. Exp. Mar. Biol. Ecol., 161 (1992) 57–77

JEMBE 01806

Pedal mucus and its influence on the microbial food supply of two intertidal gastropods, *Patella vulgata* L. and *Littorina littorea* (L.)

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[a] *Department of Environmental Biology, University of Manchester, Manchester, UK;* [b] *Port Erin Marine Laboratory, University of Liverpool, Port Erin, Isle of Man, UK*

(Received 27 November 1991; revision received 24 March 1992; accepted 5 April 1992)

Abstract: The pedal mucus secreted by intertidal gastropods has been shown to be energetically expensive. Some of this energy may be recycled through ingestion. In this paper we show that mucus persists for long enough on the shore to allow for its re-ingestion and that it can adhesively trap microalgal food particles. The pedal mucus of *Patella vulgata* L. persists about twice as long (up to ≈ 80 days) as that of *Littorina littorea* (L.) in field and laboratory experiments. Persistence varies temporally and with location on the shore. Determination of chlorophyll *a* and direct observation of diatom number were used in field experiments as indices of organic matter adhering to pedal mucus. The mucus of *P. vulgata* collected more microalgae than did the mucus of *L. littorea* or no mucus at all and more microalgae was collected on the most exposed of three shores tested. The chlorophyll *a* results suggest that the mucus loses its ability to trap microalgae with time of exposure while direct observations of diatom number suggest the contrary. Electron microscopy revealed a clumped microdistribution of diatoms which was independent of the presence of mucus or the capability of independent movement in diatoms. More raphed diatoms were observed on mucus-coated surfaces than on non-mucus-coated surfaces. The results are discussed in terms of the likelihood of intertidal gastropods using mucus trails to trap food particles and the wider implications of this phenomenon for community ecology.

Key words: Benthos; Diatom; *Littorina*; Microalga; Mucus; *Patella*

Wat. Res. Vol. 26, No. 12, pp. 1691–1693, 1992
Printed in Great Britain.

RESEARCH NOTE

HEAVY METALS IN SEAWATER: EFFECTS ON LIMPET PEDAL MUCUS PRODUCTION

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(First received July 1991; accepted in revised form May 1992)

Abstract—Toxicological modification of molluscan mucus production has largely been ignored. This is probably due to an underestimation of the rôle of mucus in molluscan physiology and its energetic cost. This paper reports that laboratory exposure to episodic doses of waterborne copper and zinc serve to reduce pedal mucus production by the common limpet *Patella vulgata* L. to about 60% of the unstressed rate. The metals are effective in this respect at concentrations as low as 10 μg l^{-1}, which in the case of zinc is below the current U.K. environmental quality standard. All metal doses reduced mucus production to the same level. This suggests a behavioural response of the limpet, limiting activity. The reduction in mucus production has important consequences both for limpet ecology and for the ways in which biological energy allocation and transformation are assessed.

Key words—behaviour, copper, heavy metals, limpet, mucus, *Patella*, zinc

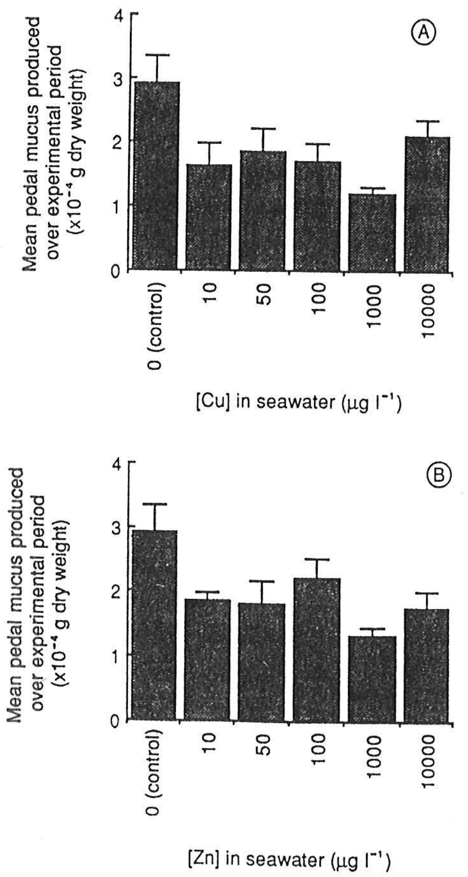

Fig. 1. Mean pedal mucus production over a 6-h period ($\pm$SE) by *P. vulgata* immersed in filtered (0.2 μm) seawater to which concentrations of (A) Cu and (B) Zn had been added. Control rates determined in filtered seawater without the addition of heavy metals.

Reference: *Biol. Bull.* **203:** 338–346. (December 2002)

Biochemical Differences Between Trail Mucus and Adhesive Mucus From Marsh Periwinkle Snails

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Department of Biology, Center for Natural Sciences, Ithaca College, Ithaca, New York 14850

Abstract. The composition of the adhesive form of marsh periwinkle mucus was compared to the trail mucus used during locomotion. The trail mucus consists primarily of large, carbohydrate-rich molecules with some relatively small proteins. In contrast, the adhesive mucus has 2.7 times as much protein with no significant difference in carbohydrate concentration. The resulting gel has roughly equal amounts of protein and carbohydrate. This substantial increase in protein content is due to the additional presence of two proteins with molecular weights of 41 and 36 kD. These two proteins are absent from the trail mucus. Both proteins are glycosylated, have similar amino acid compositions, and have isoelectric points of 4.75. This change in composition corresponds to an order of magnitude increase in tenacity with little clear change in overall concentration. The difference between adhesive and non-adhesive mucus suggests that relatively small proteins are important for controlling the mechanics of periwinkle mucus.

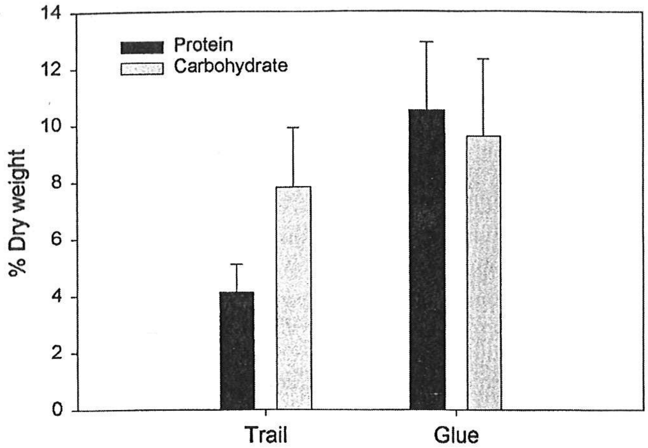

Figure 1. Comparison of the protein and carbohydrate content by dry weight of the two forms of periwinkle mucus. Six to ten pooled samples of each type were tested, with each pooled sample containing mucus from about 10 snails.

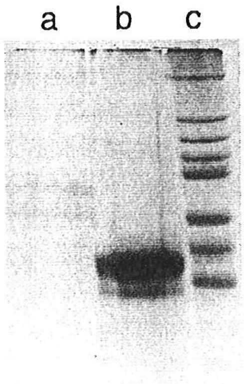

Figure 2. SDS-PAGE comparison of marsh periwinkle trail mucus (a) and adhesive mucus (b). Molecular weight markers are in lane c and have the following molecular weights: 205, 116, 97, 84, 66, 55, 45, and 36 kD. Both forms of mucus were fully dissolved by heating in the sample buffer.

Marine Biology (1995) 122: 87–94

J. Erlandsson · V. Kostylev

Trail following, speed and fractal dimension of movement in a marine prosobranch, *Littorina littorea*, during a mating and a non-mating season

Received: 19 September 1994 / 18 November 1994

Abstract We quantitatively studied movement behaviour in the gastropod *Littorina littorea* in laboratory experiments during periods of their non-mating season (November 1992) and their mating season (April–May 1993). Snails were collected in 1992 and 1993 from one boulder shore on the north west coast of Sweden. In a comparison between the two seasons (one non-mating and one mating) we measured trail complexity of unsexed snails using fractal dimension, the degree of mucus trail following (coincidence index of marker and tracker trails) and average movement speed of marker and tracker snails. We found no differences in fractal dimension and coincidence index of trails between the two seasons. Tracker snails moved, however, significantly faster than marker snails during both seasons. This could not be explained by trackers, when locomoting, using the mucus trail deposited by the marker to increase their speed, since there was no correlation between coincidence index and tracker speed. During the mating season we also conducted trail complexity, trail following and speed experiments comparing the behaviour of males and females. There was no difference between males and females in the fractal dimension of movement, nor was there any difference between the mean speed of male and female snails, although male marker snails tended to move faster than female marker snails. Males tracking other males, females tracking other females and females tracking males followed trails about equally long distances (i.e., coincidence indices did not differ). In contrast, males following female mucus trails showed a significantly higher degree of trail following than the other sex combinations. This new finding may suggest that females of *L. littorea* release pheromones in their mucus trails and that males are able to identify them.

Journal of the Marine Biological Association of the United Kingdom, 2009, 89(6), 1133–1136.
doi:10.1017/S0025315409000150 Printed in the United Kingdom

Cue synergy in *Littorina littorea* navigation following wave dislodgement

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[1]School of Biological Sciences, Flinders University, GPO Box 2100, Adelaide SA 5001, Australia, [2]South Australian Research and Development Institute, Aquatic Sciences, West Beach SA 5022, Australia

Under the assumption that dislodged intertidal gastropods have developed some adaptations to return to their original habitat, we investigated the cues involved in the navigation ability of Littorina littorea, *following a simulated wave-dislodgement. Return rates decreased by 2 and 4-fold in the absence of chemical cues at the surface of the sediment and the rock, respectively. The 19-fold decrease in return rates observed in the absence of both cues suggests their synergistic effect on* L. littorea *navigation. Chemoreception might be much more involved in the navigation and the survival of intertidal gastropods following wave dislodgement than previously thought.*

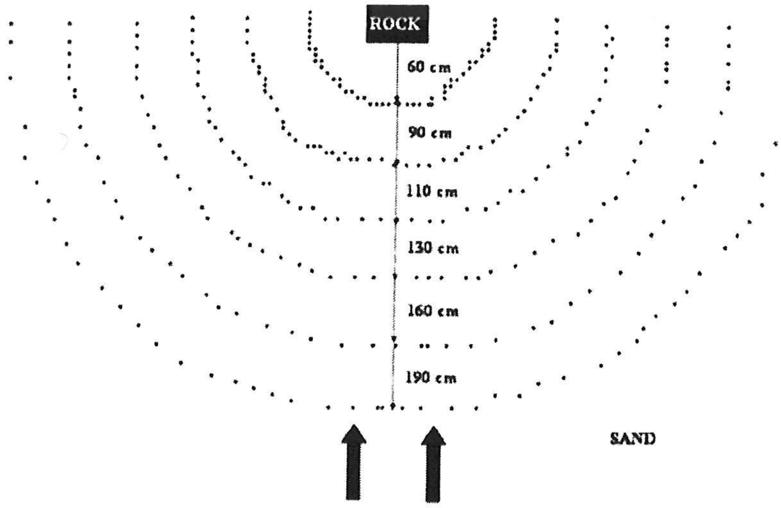


Fig. 1. Schematic top view of the experimental area. Black points are *Littorina littorea* individuals (N = 100 per distance) dislodged from the rock (black rectangle) and relocated at increasing distances (60, 90, 110, 130, 160 and 190 cm) on the sand. The black arrows indicate the water flow direction during flood tide. A total of 1200 individuals were used for each set of experiments.

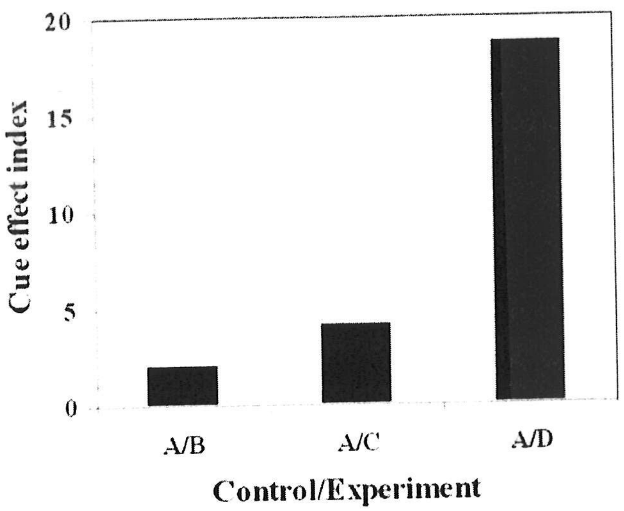


Fig. 2. Cue effect index of *Littorina littorea*. Cue effect index was estimated as the ratio between the mean return rate observed in Experiment A (26.5 ± 3.7%, control experiment), those observed in Experiment B (12.7 ± 1.5%, sand-borne cues removed), Experiment C (6.3 ± 0.4%, rock-borne cues removed) and Experiment D (1.4 ± 0.2%, both rock-borne and sand-borne cues removed). A total of 1200 individuals were used for each set of experiments.

Megathura crenulata (Archaeogastropoda)

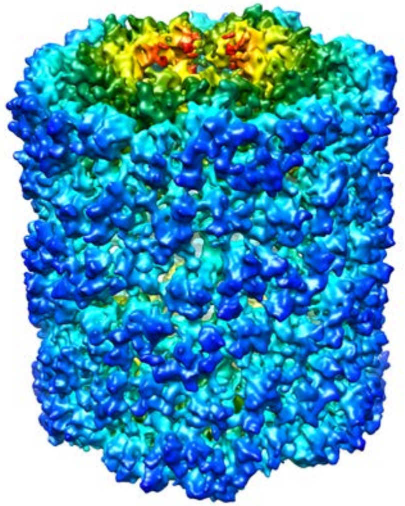
General description

Gastropod hemocyanins are massive glycoproteins (4 to 8 MDa) designed by an intricate arrangement of 10 subunits that are self-assembled into hollow cylinders 35 nm in diameter.[3]

Hemocyanin is a high molecular weight copper containing glycoprotein. It reversibly binds oxygen and forms the extra-cellular respiratory protein of mollusks. Keyhole limpet hemocyanin (KLH) is filtered from the hemolymph of *Megathura crenulata*, also called the giant keyhole limpet. It is native to the southern California coast and Mexico.

KLH

Prix: €5,33 / mg



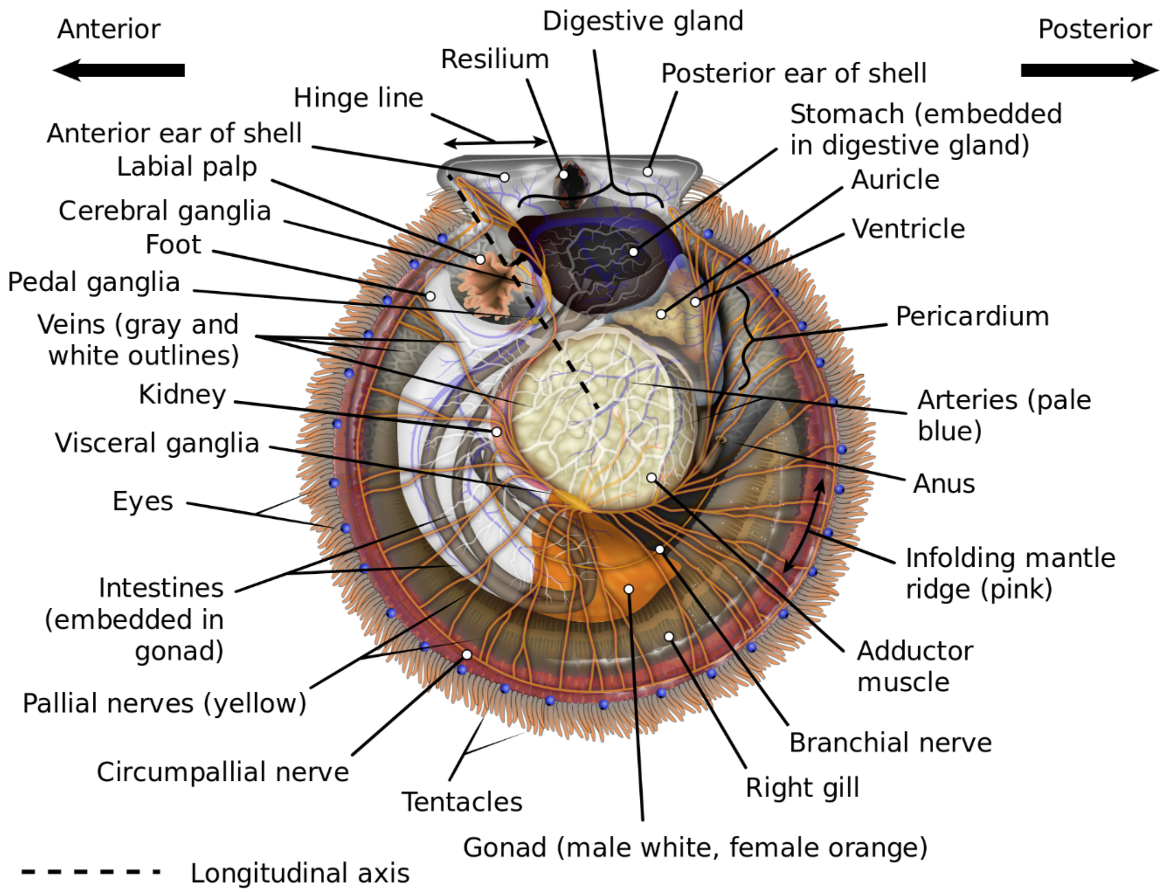
KLH: Importance pharmacologique, médicale, économique

(1) Traitement du cancer de la vessie

(2) Transporteur de vaccin (antigène)

(3) Approche therapeutique nouvelle: immunostimulation (recherche)

Hemocyanin is one of the strongest antigens known. The approach involves the use of highly immunogenic molecule like the hemocyanin for non-specific immunostimulation (NSI) or active specific immunostimulation (ASI) using conjugate vaccines, wherein the tumor (disease) specific antigens are covalently bound to carrier protein like KLH and the product used in human clinical studies. http://www.biovision.com/hemocyanin-keyhole-limpet-klh-native-7523.html



Anterior
Posterior
Digestive gland
Resilium
Posterior ear of shell
Hinge line
Stomach (embedded in digestive gland)
Anterior ear of shell
Labial palp
Auricle
Cerebral ganglia
Ventricle
Foot
Pedal ganglia
Pericardium
Veins (gray and white outlines)
Kidney
Arteries (pale blue)
Visceral ganglia
Anus
Eyes
Infolding mantle ridge (pink)
Intestines (embedded in gonad)
Adductor muscle
Pallial nerves (yellow)
Branchial nerve
Circumpallial nerve
Right gill
Tentacles
Gonad (male white, female orange)
Longitudinal axis

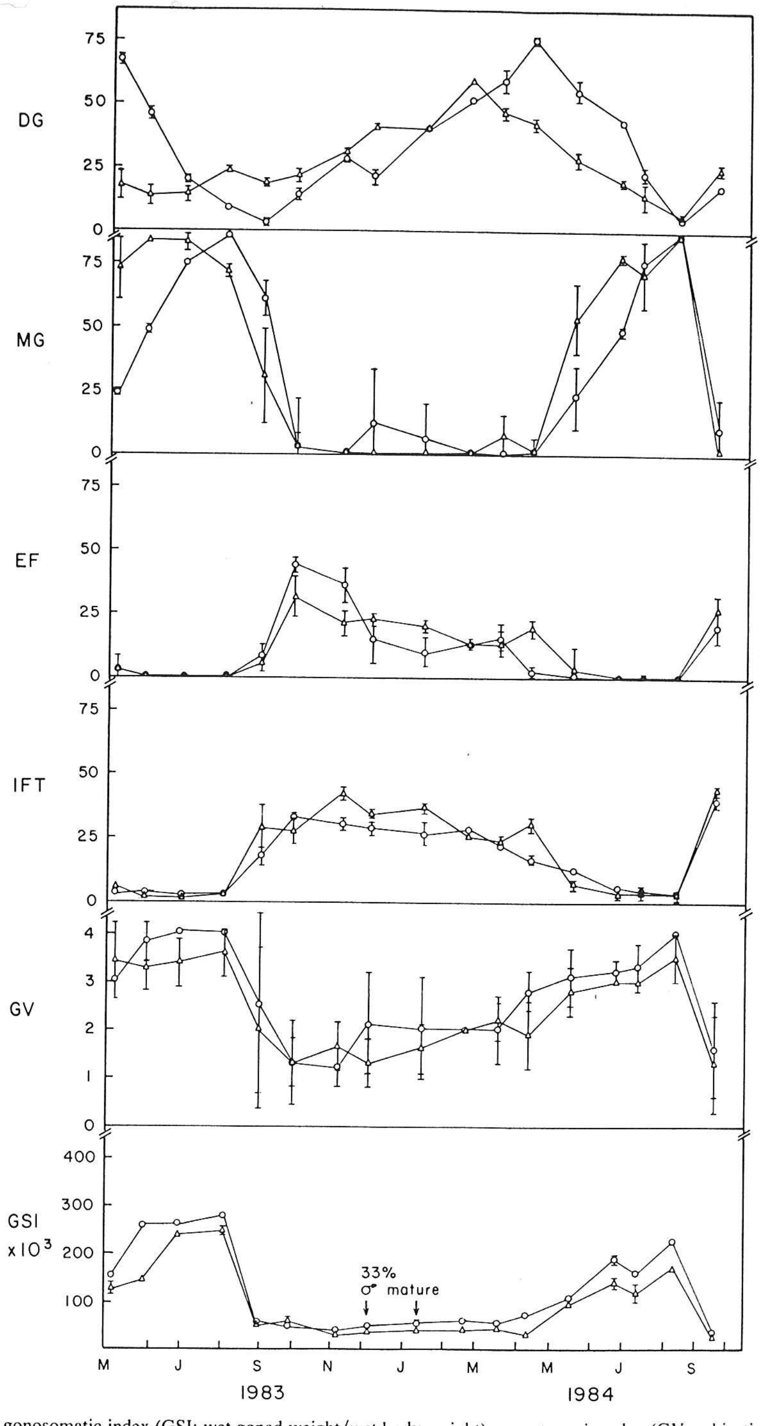
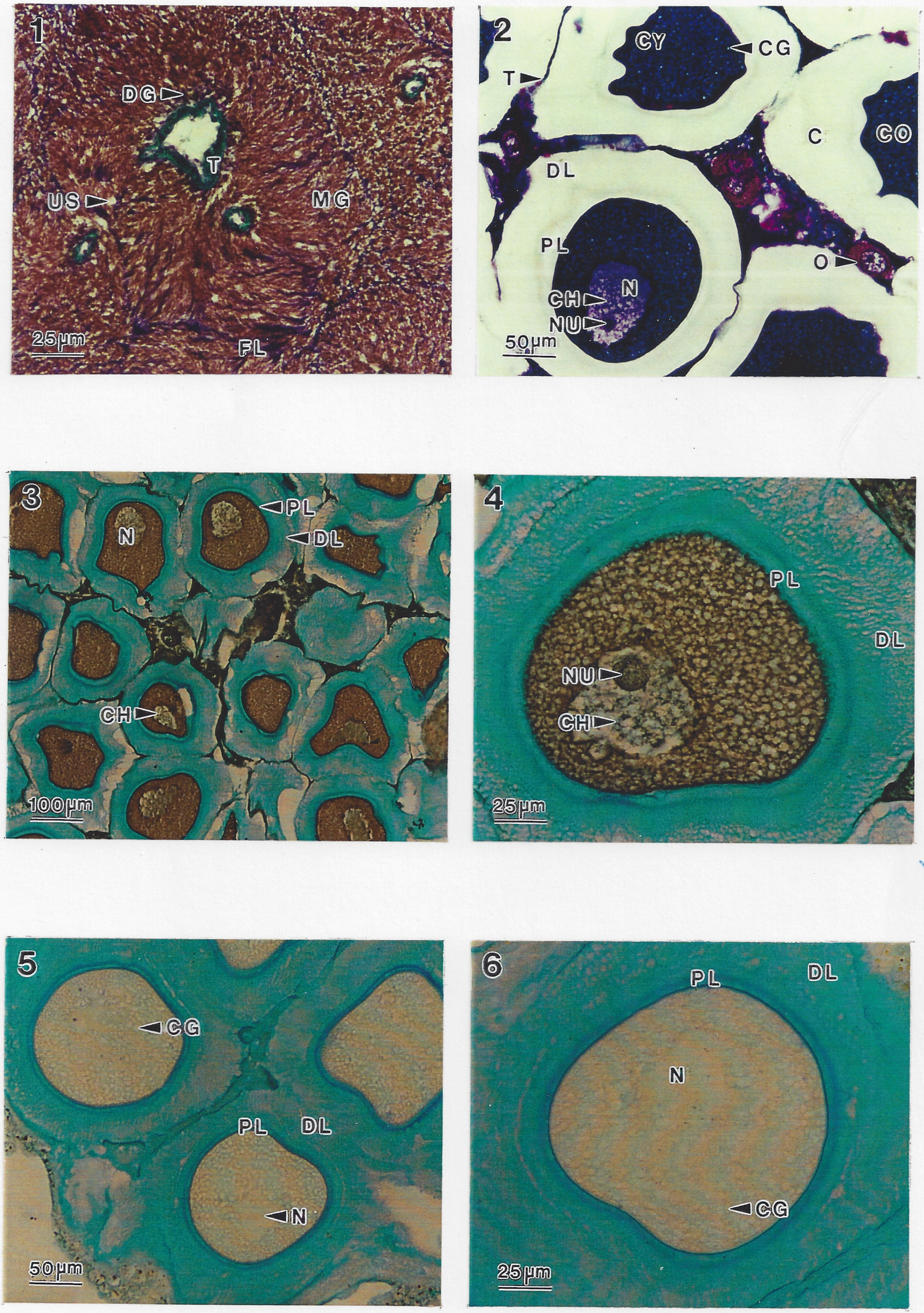


FIG. 1. Mean ± SD gonosomatic index (GSI: wet gonad weight/wet body weight), gametogenic value (GV: subjective staging), and gamete volume fraction (% gonad volume) values of male (○) and female (△) *P. magellanicus* from Chamcook Bay (Bay of Fundy), May 1983 – September 1984. Abbreviations for gamete volume fractions: IFT, interfollicular tissue; EF, empty follicular space; MG, mature gametes; DG, developing gametes. Note: Gametogenic values were assigned as in Robinson et al. (1981).


1
DG
T
US
MG
FL
25µm
2
CY
CG
T
C
CO
DL
PL
N
CH
NU
O
50µm
3
PL
DL
N
CH
100µm
4
PL
DL
NU
CH
25µm
5
CG
PL
DL
N
50µm
6
PL
DL
N
CG
25µm

Journal of Shellfish Research, Vol. 20, No. 1, 301–307, 2001.

REPRODUCTIVE CHARACTERISTICS OF THE ARCHAEOGASTROPOD *MEGATHURA CRENULATA*

PETER G. BENINGER,[1,*] ROZENN CANNUEL,[1] JEAN-LOUIS BLIN,[2] SÉBASTIEN PIEN,[2] AND OLIVIER RICHARD[2]

[1]*Laboratoire de Biologie Marine, ISOMer, Faculté des Sciences et Techniques, Université de Nantes, 44322 Nantes Cedex, France;* [2]*Syndicat Mixte pour l'Equipement du Littoral, Zone conchylicole, 50560 Blainville sur Mer, France*

ABSTRACT A histological and histochemical study was performed on individuals of the archaeogastropod *Megathura crenulata* sampled in the field, in order to ascertain the fundamental features of reproductive biology in this species. Basic aspects addressed were gonad and gamete structure, nature of vitelline reserves, and composition of oocyte coat. Stereological counts and oocyte measurements were performed to obtain a quantitative assessment of the reproductive cycle from June 1999 to June 2000. No simultaneous hermaphrodites were observed. The gonad structure of *M. crenulata* consisted of traversing trabeculae from which gametes developed centrifugally. The gonads of both males and females were homogeneous, allowing reliable data to be obtained from a single histological sample of each individual. Mature gametes greatly dominated the profile throughout the study period; coated oocyte diameters were also very stable. These techniques, routinely applied to the study of reproductive cycles, did not allow the identification of spawning preparedness in this species. Vitelline reserves were dominated by non-staining (putatively lipid) vacuoles; no appreciable quantities of glycogen were observed. The oocyte coat was chiefly composed of acid mucopolysaccharides, conferring both mechanical and antimicrobial protection, as well as limiting egg and larval dispersal.

KEY WORDS: *Megathura crenulata*, Gastropoda, gonads, gametes, reproductive cycle, histochemistry

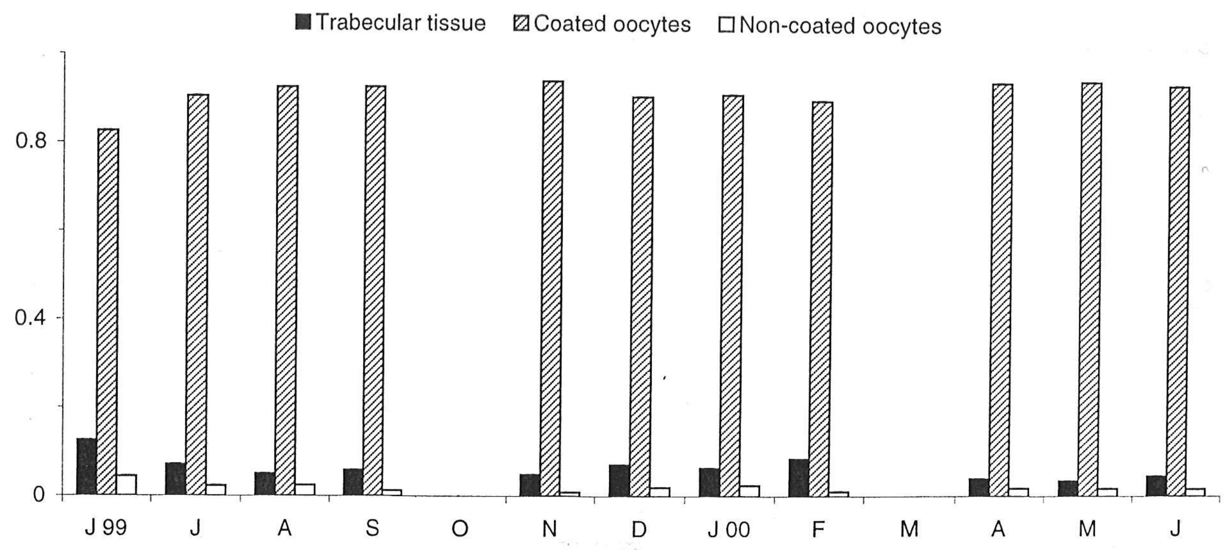


Figure 5. *M. crenulata.* Evolution of tissue volume fractions in females, June 1999 to June 2000. The 95% confidence intervals are too small to be seen. Data unavailable in October and March due to sampling difficulties.

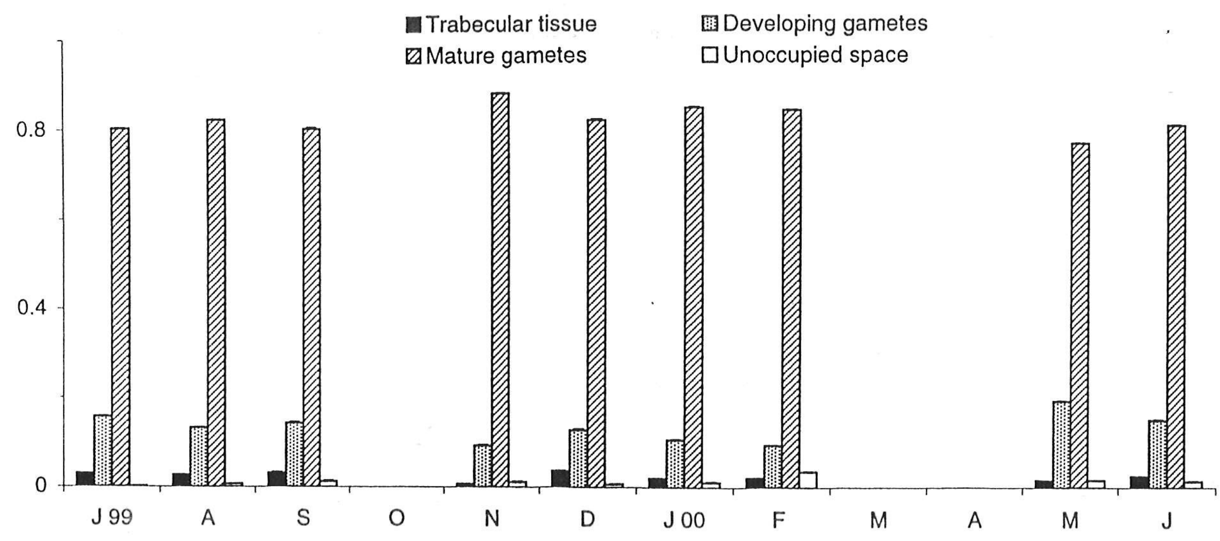


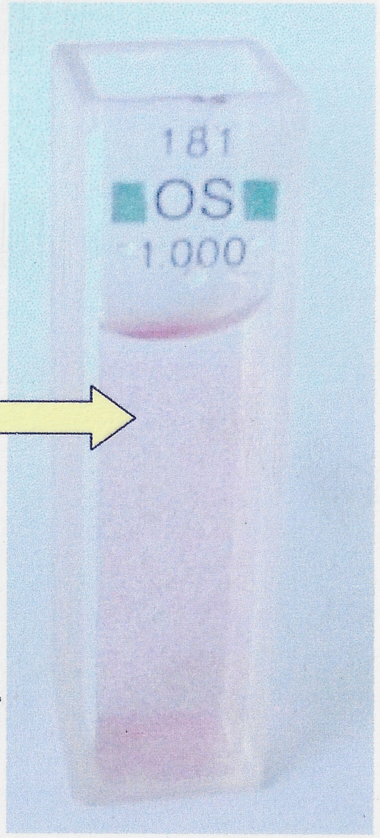
Figure 3. *M. crenulata.* Evolution of tissue volume fractions in males, July 1999 to June 2000. The 95% confidence intervals are too small to be seen. Data unavailable in October, March, and April due to sampling difficulties.

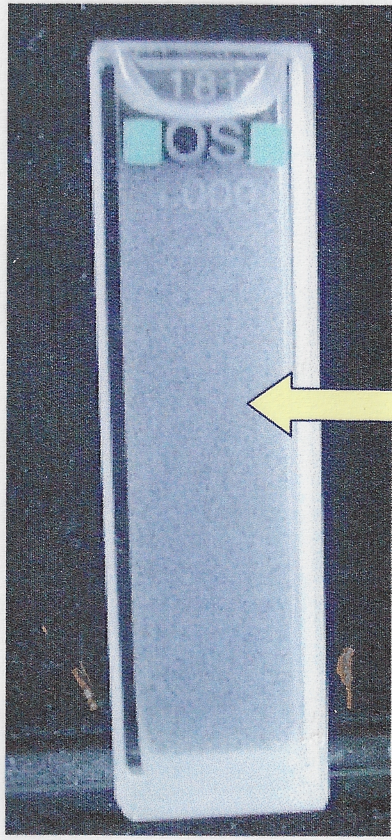
— *Matériel et méthodes*

Ovocytes colorés en suspension

↓

Mesures spectrophotométriques

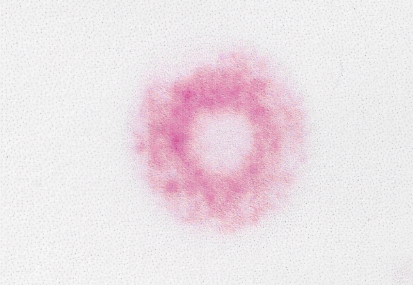




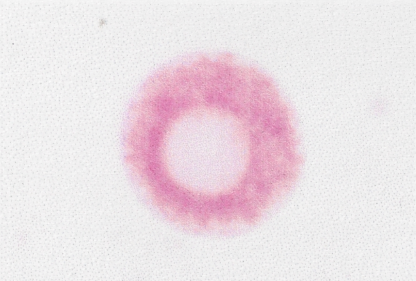
Témoin

Perspectives

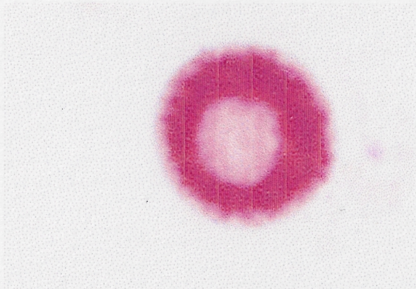
Quantification possible des ovocytes en fonction de l'intensité de leur coloration



➡ % ovocytes peu colorés



➡ % ovocytes moyennement colorés



➡ % ovocytes très colorés

⇨ Estimation des proportions des différents types d'ovocytes pour chacune des femelles

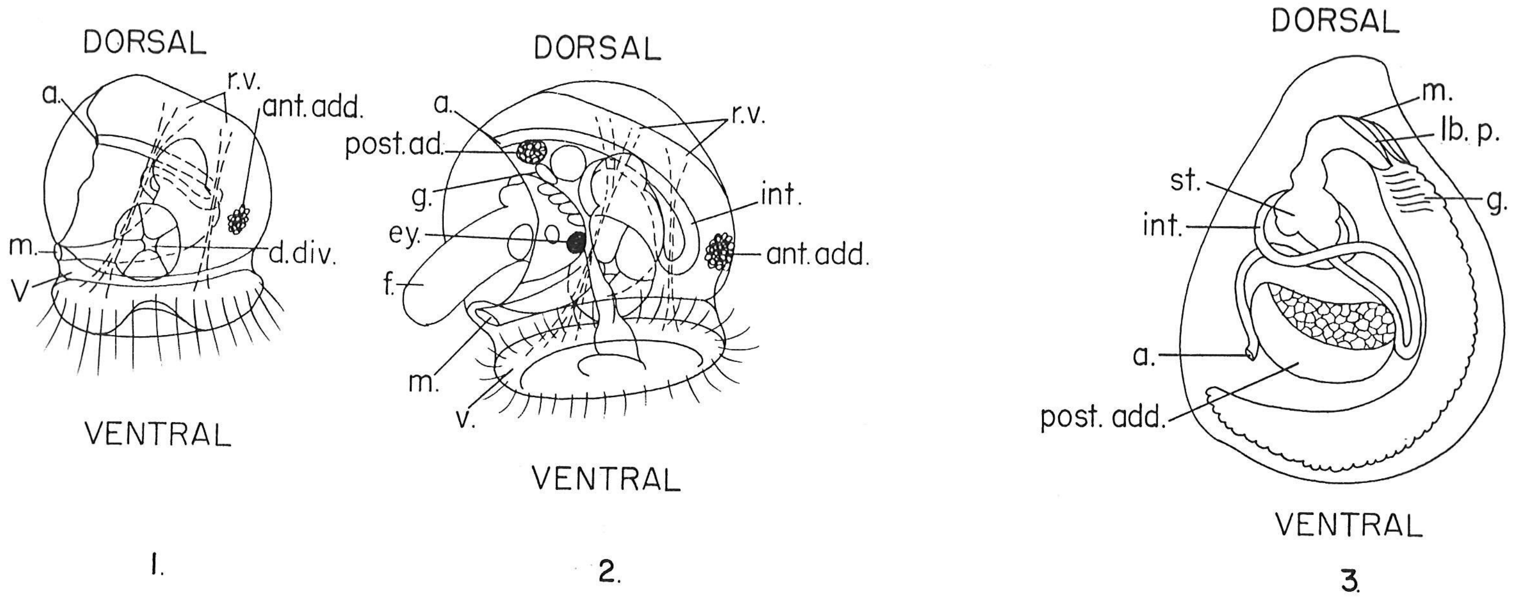


FIGURE 352.—Diagram showing the changes in the topographical relation of various organs of *O. edulis* during the transition from free-swimming larva (1) to fully developed larva ready to set (2) and juvenile oyster (3). From Erdmann (1935). a.—anus; ant. ad.—anterior adductor; ey.—eye; f.—foot; g.—gills; int.—intestine; l.p.—labial palps; post. ad.—posterior adductor; r.v.—retractors of velum; v.—velum.

Tableau 3-3. — LES 3 TYPES DE CONCHYLICULTURE.

STADES DE DÉVELOPPEMENT	CULTURE DU JEUNE À L'ADULTE	CULTURE DE LA POSTLARVE À L'ADULTE	CULTURE DE L'OEUF À L'ADULTE
GÉNITEURS OEUF LARVE VÉLIGÈRE PÉDIVÉLIGÈRE			CONDITIONNEMENT ↑ ECLOSERIE ↓
POSTLARVE OU PETIT NAISSAIN		CAPTAGE ↑ COLLECTEURS ↓	↑ NOURRICERIE ↓
JEUNE OU NAISSAIN DE CULTURE		DETROQUAGE	
ADULTE	↑ PARC D'ENGRAISSEMENT ↓	↑ PARC D'ENGRAISSEMENT ↓	↑ PARC D'ENGRAISSEMENT ↓
	BASSIN D'AFFINAGE	BASSIN D'AFFINAGE	BASSIN D'AFFINAGE

J. Exp. Mar. Biol. Ecol., 1986, Vol. 95, pp. 99–103
Elsevier

JEM S618

Short Communication

VARIATION OF RELATIVE ORGANIC MATTER IN *MYTILUS EDULIS* L. LARVAE AND POSTLARVAE

ALBERT LUCAS, LILA CHEBAB-CHALABI and PETER BENINGER[1]
Laboratoire de Zoologie, Faculté des Sciences, Université de Bretagne Occidentale, 29287 Brest Cedex, France

(Received 14 October 1985; accepted 1 November 1985)

Abstract: The variations in relative organic matter (ROM: organic matter/total dry weight) were studied in larval cultures of *Mytilus edulis* L. reared at 15 °C and at 20 °C, using single and mixed algal diets. A characteristic inverted peak is observed prior to metamorphosis, with higher minimum values in cultures reared at 20 °C and fed a mixed algal diet. The shape of the ROM curve appears to reflect major physiological events in *M. edulis* larvae and is thus appropriate as a convenient condition index from the first larval stages to the post-larval phase.

Key words: organic matter; larvae; postlarvae; *Mytilus edulis*

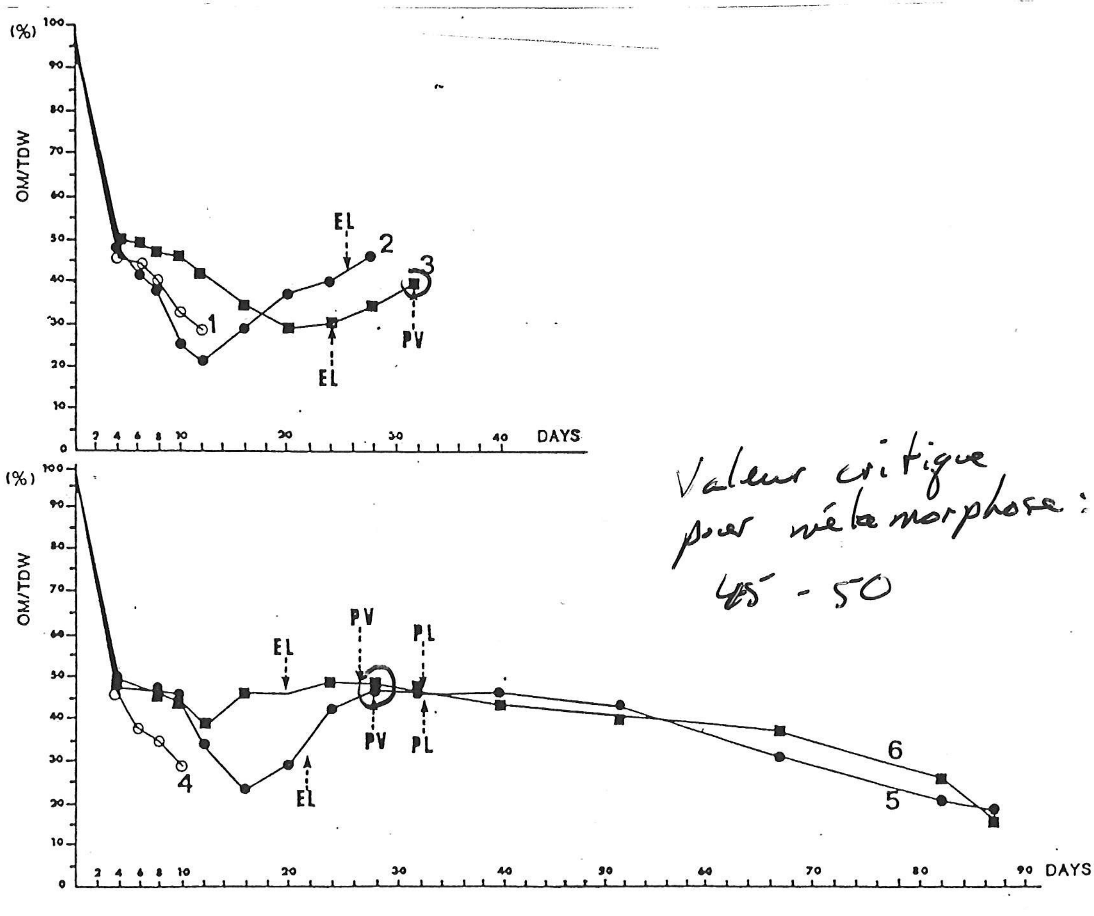


Fig. 1. The index OM/TDW (%) in *Mytilus edulis* larvae reared at 15 °C (curves 1,2,3) and at 20 °C (curves 4,5,6): curves 1 and 4, unfed larvae; curves 2 and 5, larvae fed with *Pavlova*; curves 3 and 6, larvae fed with *Pavlova*, *Isochrysis* and *Dunaliella*; EL, eyed larvae; PL, post-larvae; PV, pediveliger larvae.

Valeur critique pour métamorphose : 45 - 50

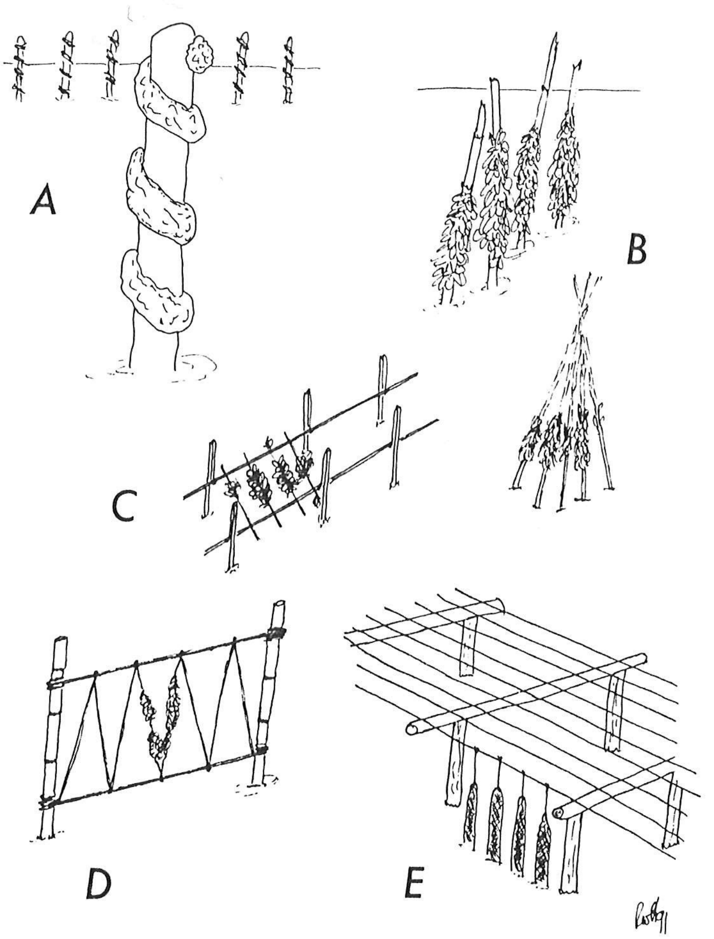


Fig. 10.1. Diagrammatic representation of various methods of fixed-suspended cultivation. A: bouchot; B: bamboo pole; C: rack and rod; D: rope-web; E: hanging park.

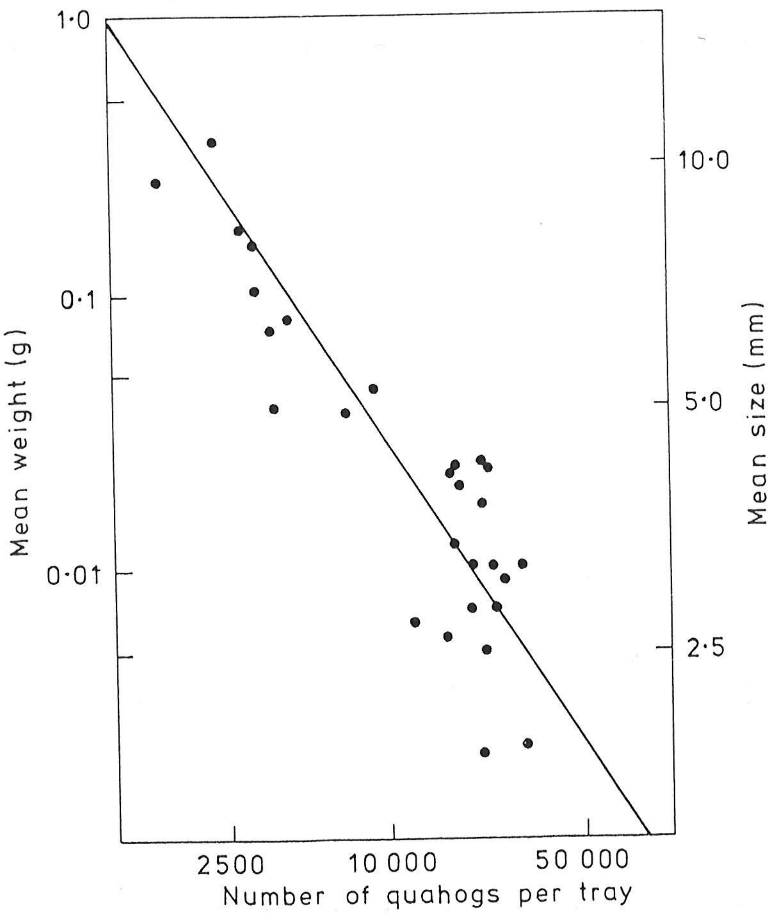


Fig. 31 The relation between quahog size and the number per $900cm^2$ tray (curve drawn by eye).

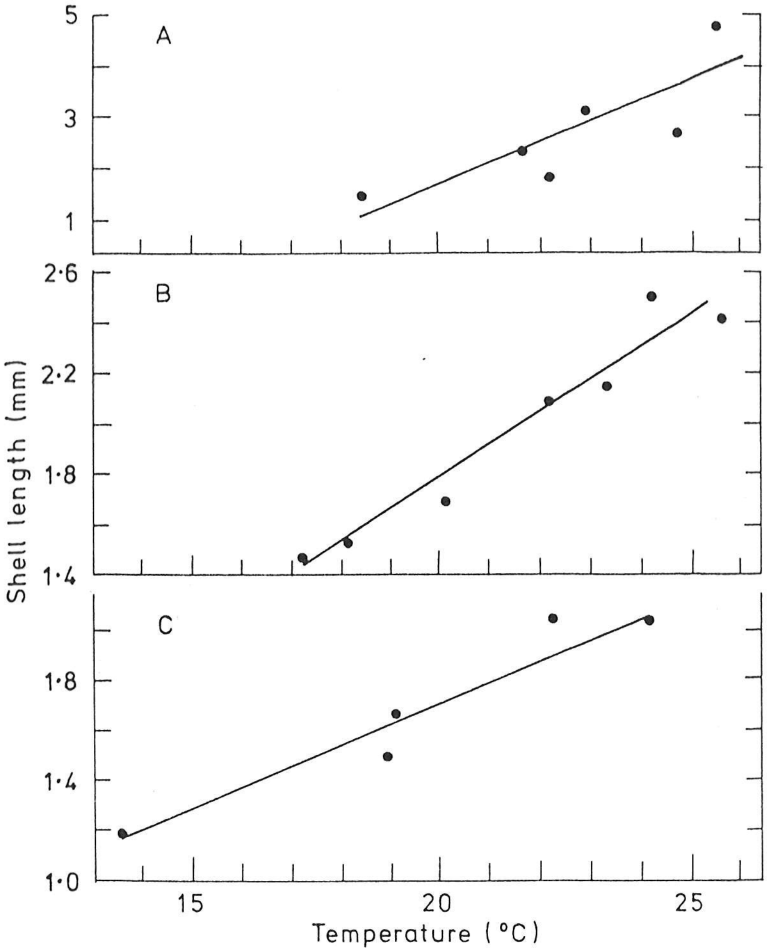


Fig. 25 The shell length of spat grown at various temperatures: (A) *Ostrea edulis* for 17 days after metamorphosis, (B) *Mercenaria mercenaria* for 28 days — initial size 1.05mm and (C) *Venerupis decussata* for 21 days — initial size 1.00mm.

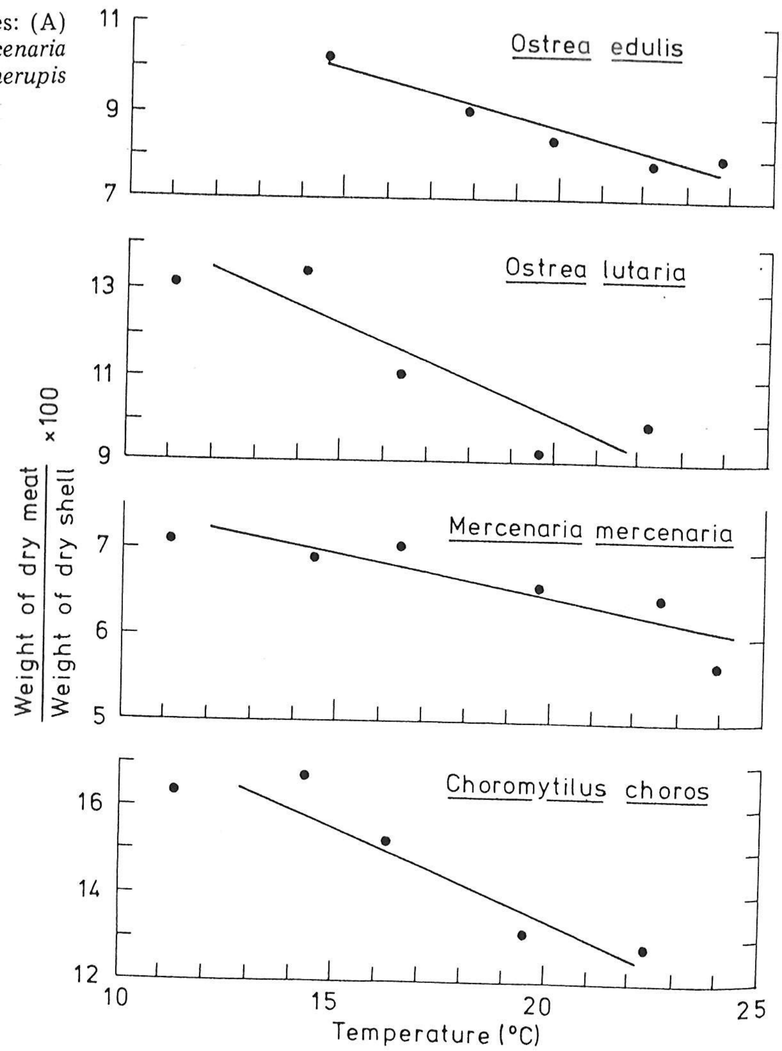


Fig. 26 The ratio between weight of meat and weight of shell in spat grown at various temperatures.

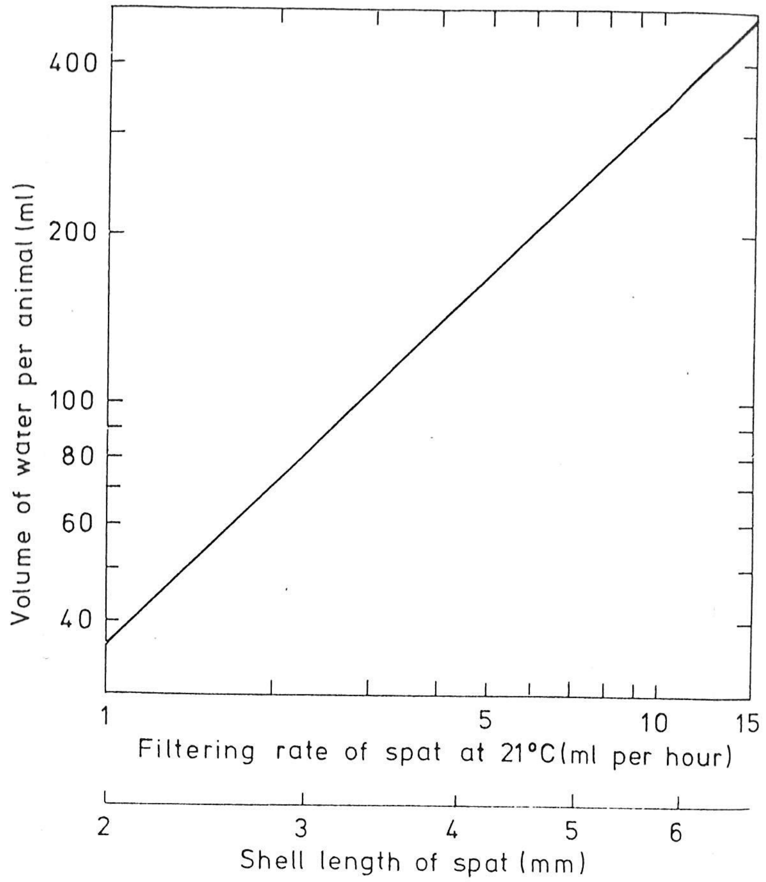


Fig. 21 The volume of water required by oyster spat of various sizes to give a 50% reduction in food concentration in 24 hours.

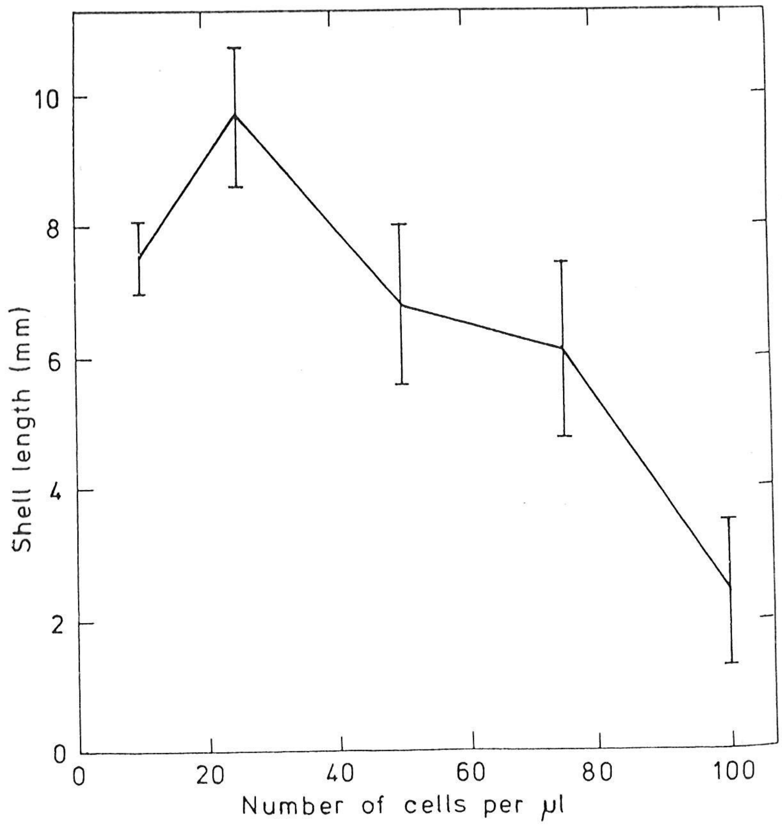


Fig. 23 The average size of oyster (*O. edulis*) spat 47 days after settlement when fed on various densities of *Isochrysis*. The vertical bars indicate the 95% confidence limits.

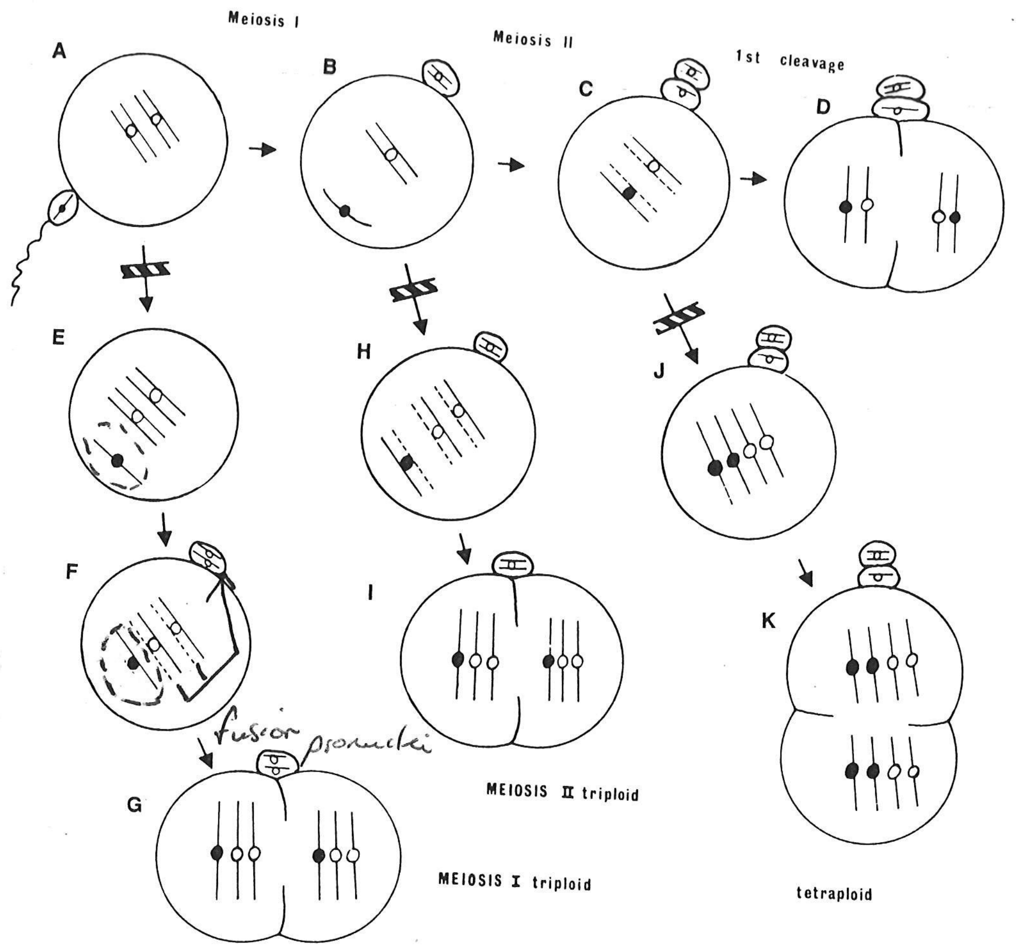
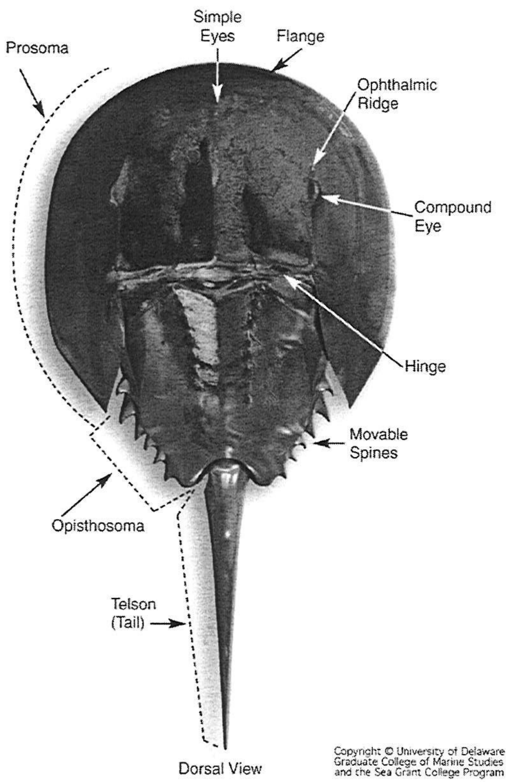


Fig. 10.8. Normal meiosis in the bivalve egg (A–D). For simplicity sake only one pair of chromosomes is shown. (A) Egg when released is at metaphase of meiosis I; activated by sperm. (B) Meiosis I completed, PB1 extruded, sperm nucleus enters egg. (C) Meiosis II completed, PB2 extruded, male and female pronuclei unite. (D) First cleavage mitotic division. Ploidy manipulation in the bivalve egg (E–K). (E) Shock administered during meiosis I, both chromosomes of the pair retained in the egg; PB1 not extruded. (F) Normal meiosis II allowed, PB2 extruded; 2N female pronucleus and N male pronucleus unite. (G) Triploid first cleavage. (H) Shock administered during meiosis II, PB2 not extruded; 2N female pronucleus and N male pronucleus unite. (I) Triploid first cleavage. (J) Shock administered during first cleavage. (K) Tetraploid chromosome complement in second cleavage. From Beaumont & Fairbrother (1991).

Le test Limule (LAL – Limulus amoebocyte lysate)



Prélèvement hémolymphe

↓

Centrifugation → amoebocytes

↓

Eau distillée → lyse

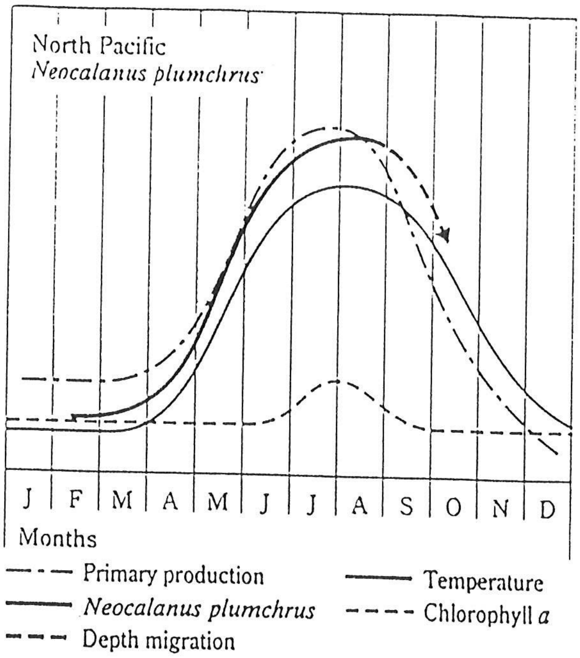
↓

Lyphilisation: coagulogène

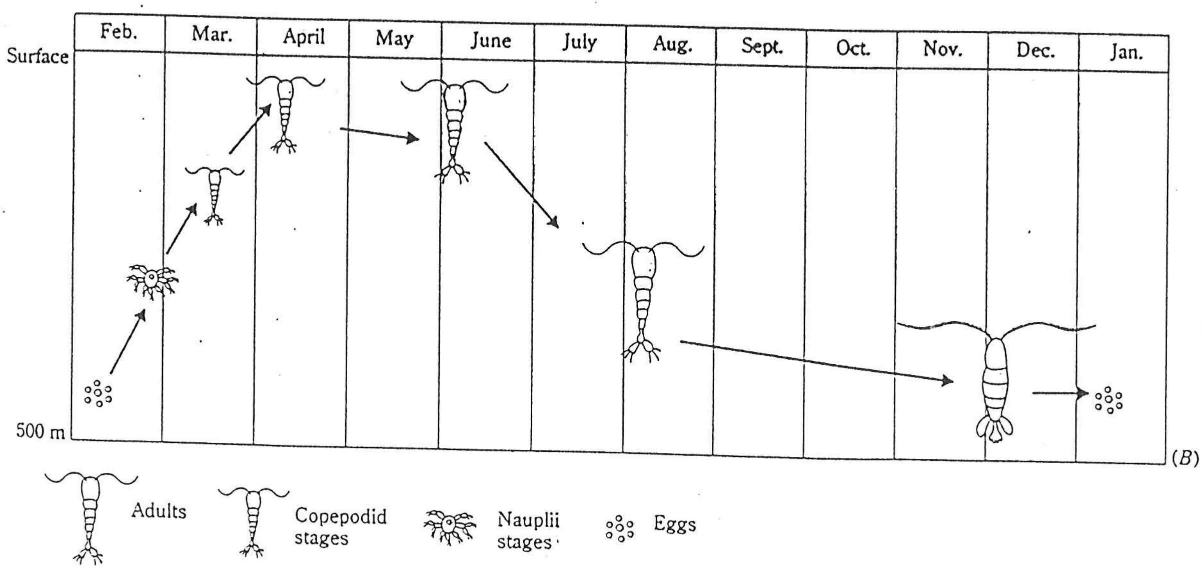
Produit à tester: sans endotoxines → **Pas de précipitation**

Produit à tester: avec endotoxines → **Précipitation**

⇓



Neocalanus plumchrus



The life cycle of *Neocalanus plumchrus* in the North Pacific Ocean.

De: Nybakken, JW Marine Biology, an ecological approach. 3rd edition. New York, Harper-Collins, 1993

Table 16.3 The species that contributed most to global aquaculture production by value in 1997. Species are classified as marine if they are reared in marine or brackish environments for part of their life cycle. Data from FAO (1999).

Species	Common name	Group	Environment	Value ($US billion)
Giant tiger prawn	*Penaeus monodon*	Crustacea	Marine	3.93
Pacific cupped oyster	*Crassostrea gigas*	Mollusc	Marine	3.23
Silver carp	*Hypophthalmichthys molitrix*	Fish	Freshwater	2.79
Common carp	*Cyprinus carpio*	Fish	Freshwater	2.42
Grass carp	*Ctenopharyngodon idellus*	Fish	Freshwater	2.23
Atlantic salmon	*Salmo salar*	Fish	Marine	1.87
Yesso scallop	*Pecten yessoensis*	Mollusc	Marine	1.62
Japanese carpet shell	*Ruditapes philippinarum*	Mollusc	Marine	1.52

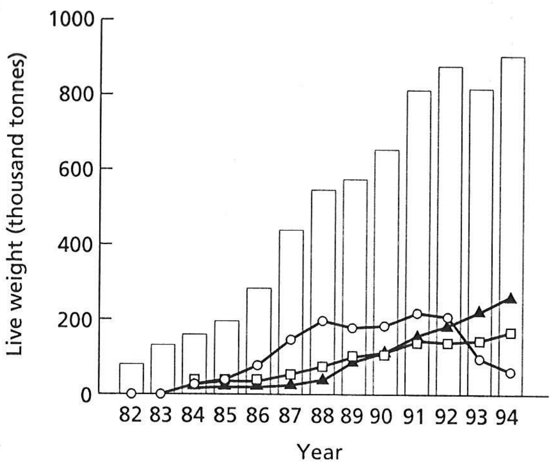
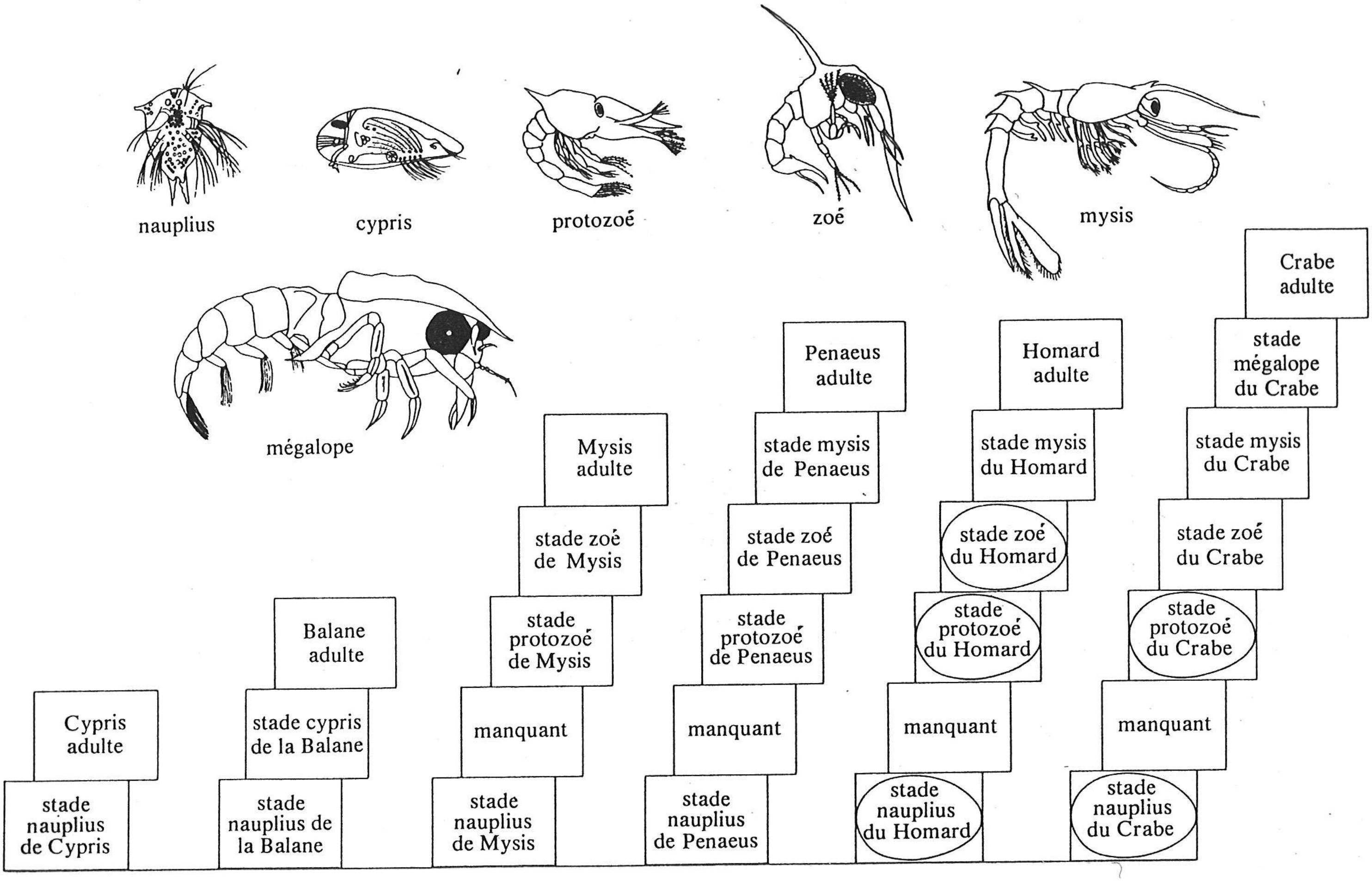


Fig. 16.5 World production of farmed penaeid shrimp (open bars) for the years 1982–94, showing the rise and decline in the production of shrimp from China. Key: China (circles); Indonesia (squares); Thailand (triangles). After Chamberlain (1997).



d'après Meglitsch, 1974

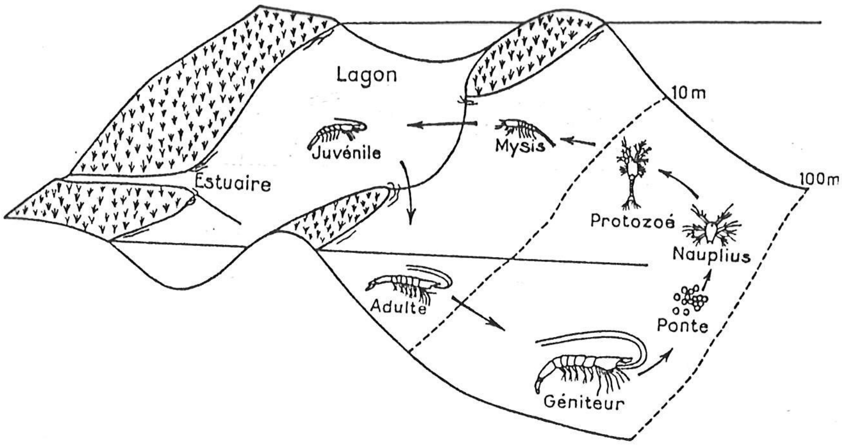


FIG. 3-18. — *Schéma du cycle biologique des Pénéidés.*

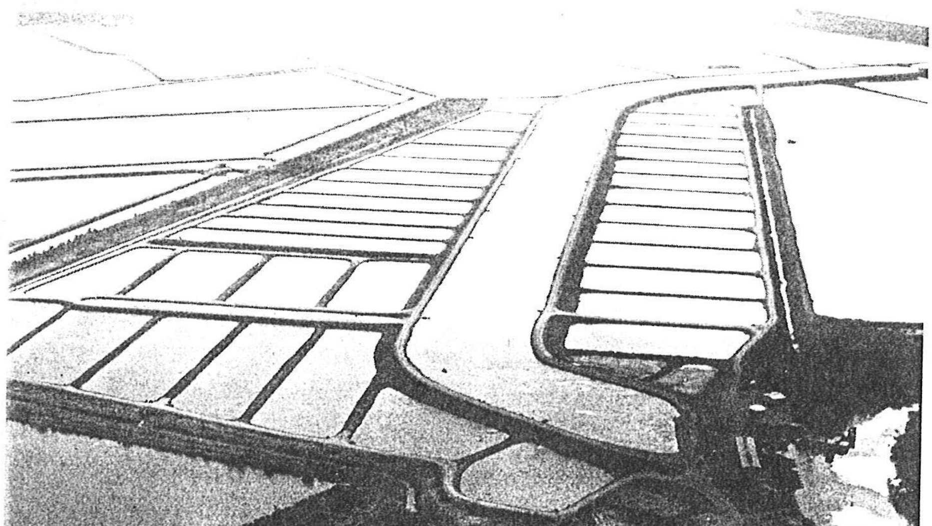


Plate 7.1 Aerial view of a large Ecuadorian shrimp farm showing the pumping station (bottom right) and supply canal (centre) bounded by nursery ponds. In the background are a number of irregularly shaped on-growing ponds of 4–25 ha.

La penéiculture: stades de vie

La péneiculture: nourriture

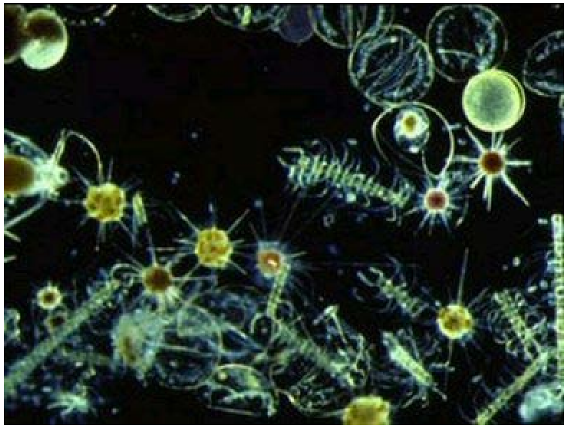


Tableau 3-16. — RÉSUMÉ CHRONOLOGIQUE DES OPÉRATIONS DE PRODUCTION DE POST-LARVES DE CREVETTES PÉNÉIDES.

Temps		*Stade*	*Longueur moyenne*	*Opérations*
Jours	*heure*			
1	06	—	—	Remplissage des bassins, à moitié de leur capacité, en eau de mer de salinité 33 à 36 ‰, filtrée/50-150 µ, pH de 7,3 à 7,5, chauffée à 26-28 °C.
1	18	femelles	—	Mise en charge à raison de 2 à 5 femelles pour 10 m³ d'eau.
1 2	22 04	œufs	230/320 µ	Apparition d'un mucus brunâtre à la surface et sur les parois. 50 % des femelles doivent avoir pondu.
2	06	»	»	Comptage des œufs (30 à 60 par litre).
2	13	œufs et nauplius	300/350 µ	Éclosion de 50 % des œufs. Comptage des nauplius (20 à 40 par litre).
2	22	»	»	Toutes les femelles doivent avoir pondu.
3	06	»	»	Retrait des femelles. Comptage des œufs et nauplius (60 à 100 par litre). Enrichissement de l'eau en sels nutritifs: NO_3K : 2ppm, PO_4HNa_2 : 0,2 ppm, SiO_4K_2 : 0,1 ppm et parfois en métaux oligodynamiques et vitamines (Thiamine, Biotine et B_{12}) pour stimuler la production de phytoplancton.
3	18	nauplius	300-420 µ	Préparations en bacs annexes d'œufs d'*Artemia salina*. Comptage du phytoplancton (plus de 10^5 cellules par cm^3).
4 4	06 18	protozoés I	850/950 µ	Enrichissement en sels nutritifs (100 à 300 % de la dose initiale) selon la richesse du phytoplancton. L'eau doit prendre une couleur de thé foncé. Si le phytoplancton est insuffisant, adjonction de vitamines et de $FeCl_3$ ou de décoction froide de son de riz tamisée à 60 µ.
5	06	protozoés I et II	1,8/2,2 mm	Transfert des œufs bourgeonnés d'*Artemia salina*, les protozoés doivent bien s'alimenter (présence de nombreuses déjections). Enrichir en sels nutritifs si nécessaire. Comptage des protozoés (60 à 80 par litre).

Temps		Stade	Longueur moyenne	Opérations
Jours	*heure*			
6 7 8		protozoés II et III	2,2/2,6 mm	Apport de nauplius jeunes puis âgés d'*Artemia*. Période la plus critique de l'élevage. Contrôle et entretien du phytoplancton. Introduction de nourriture carnée (broyat de chair de mollusque tamisée à 60 μ) à raison de 0,4 à 0,8 kg par million de larves par jour.
9		mysis I	2,7/3,2 mm	Accroître de 12 à 15 % le volume d'eau. Contrôles et distributions précédents. Le phytoplancton colore en brun l'eau. Fournir 0,2 à 0,6 kg d'œufs secs d'*Artemia* par million de larves par jour.
10		mysis I II et III	2,7/4,6 mm	Accroître de 15 à 25 % le volume d'eau. Comptage des larves (40 à 60 par litre).
12		»	»	Renouvellement de l'eau, siphonnage de l'eau usée à travers un filtre à maille de 100 μ. Contrôles et distributions précédents.
13		post-larves 1	4,6/5,1 mm	Renouvellement de 15 à 25 % de l'eau. Nourriture carnée (chair de mollusques) tamisée sur mailles de 150 μ à raison de 1,5 kg par million de post-larves et par jour, en 5 repas de 17 à 4 heures. Cesser la fourniture d'*Artemia*.
14 à 18		post-larves 1 à 5	5,0/7,5 mm	Alimentation carnée accrue chaque jour de 0,5 kg par million de post-larves. Renouvellement d'eau portée à 35 % par jour et éventuellement abaissement de la salinité à raison de 3 à 5 ‰ par jour. Limite du stockage en bassins de production de post-larves à raison de 30 post-larves par litre. Les post-larves deviennent benthiques.
19 à 28		post-larves 6 à 15	6,9/23,0 mm	Limite du stockage à raison de 10 post-larves par litre et transfert en bassin d'engraissement.

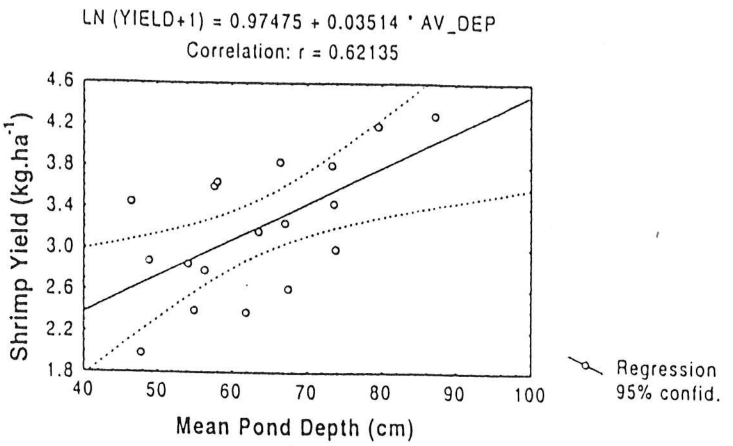


Fig. 6. Correlation between mean shrimp pond depth and shrimp yields (management technique experiment) during 1996–1997, Ca Mau province, southern Vietnam. Shrimp yield data were transformed using $\ln(n+1)$ for normality.

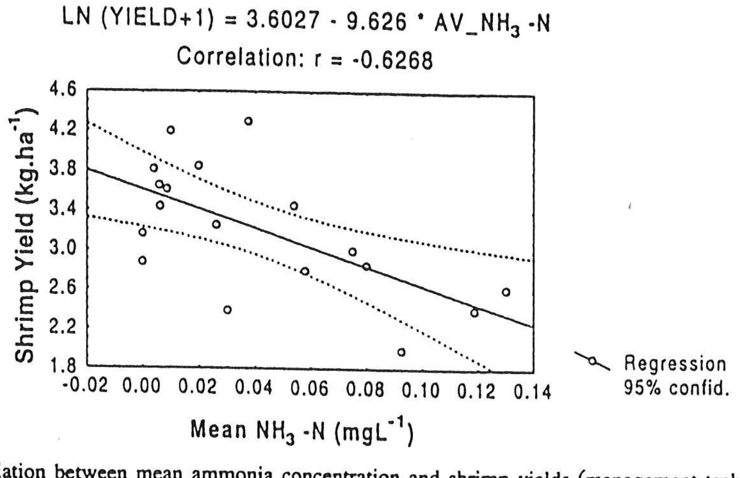


Fig. 8. Correlation between mean ammonia concentration and shrimp yields (management technique experiment) during 1996–1997, Ca Mau province, southern Vietnam. Shrimp yield data were transformed using $\ln(n+1)$ for normality.

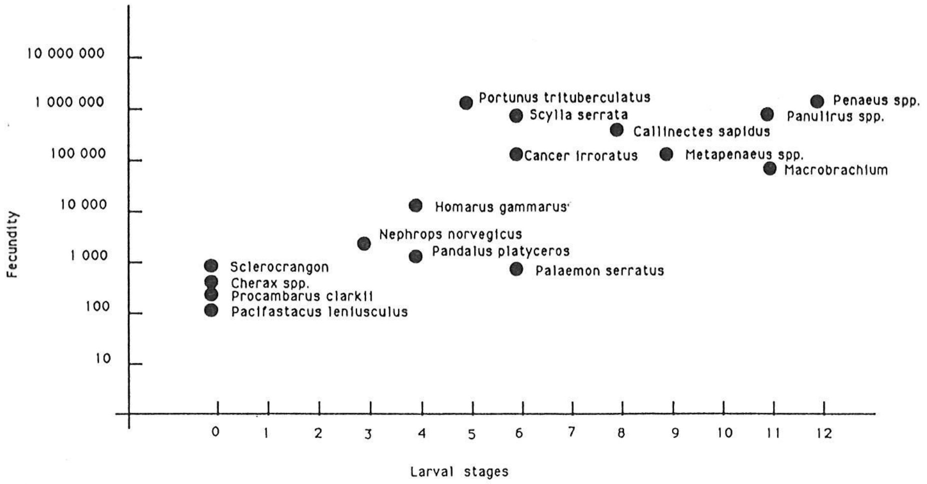


Fig. 4.1 The relationship between fecundity and the number of free-swimming larval stages in selected crustaceans.

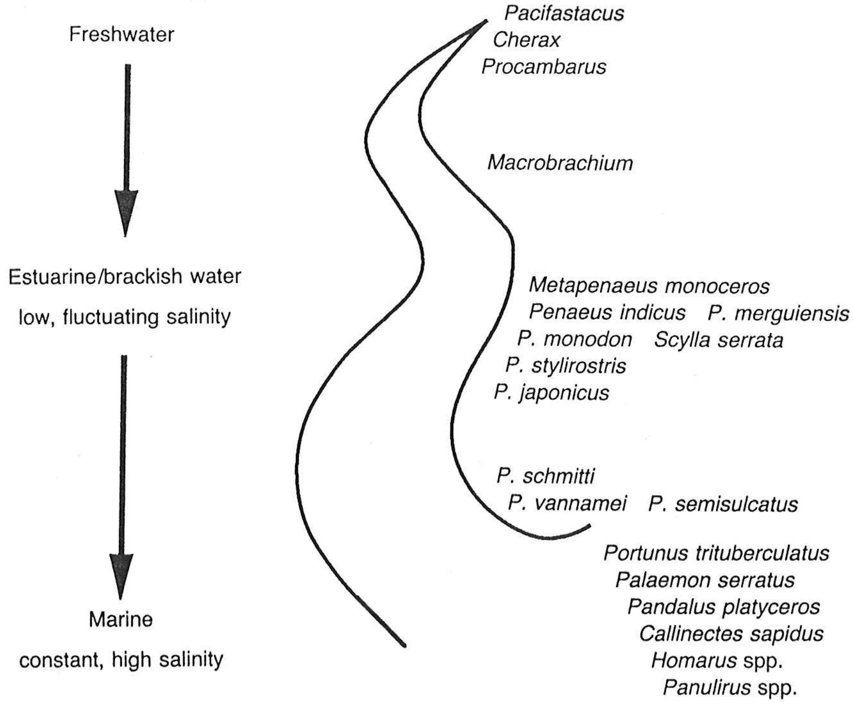


Fig. 4.2 Habitat preferences of selected crustaceans.

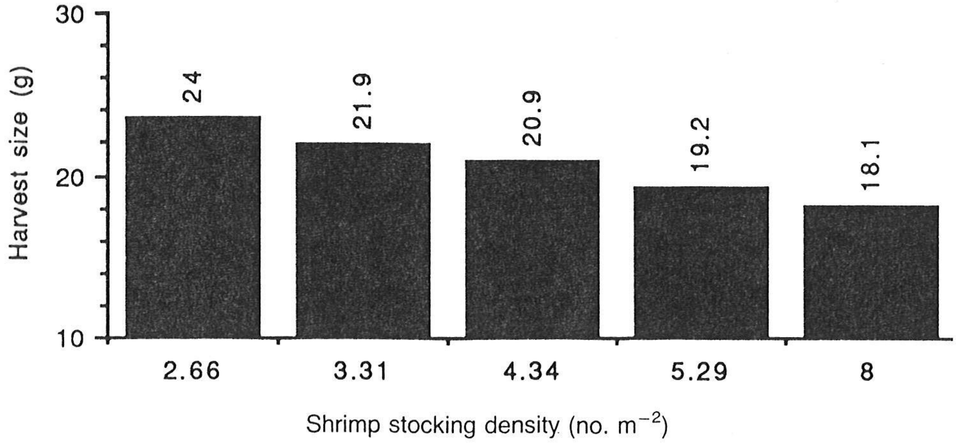
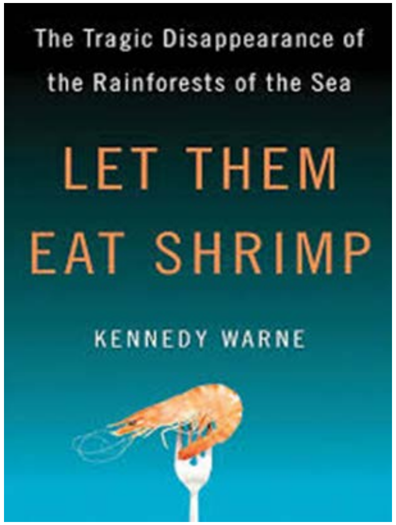


Fig. 8.4 Relationship between stocking density and harvest size for extensive/semi-intensive *P. vannamei* farming in Ecuador (based on 152 observations) (Hirono 1986).

Trop d'une bonne chose....



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Antibiotic resistance of bacteria from shrimp ponds

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Abstract

The incidence of antibiotic resistance was compared in bacteria isolated from pond water, pond sediment, water and sediment from the receiving environment (area where water from pond drains, which is 0 and 50 m away from the exit gate, in this study) and cultured shrimp from ponds that have not used any antimicrobials, ponds that have previously used antimicrobials and ponds that are currently using oxolinic acid. Most of the bacteria isolated from all sample and pond type were *Vibrios*. Among the *Vibrios*, *V. harveyi* were most commonly isolated. Multiple antibiotic resistance (MAR) to at least two antimicrobials was highest in ponds currently using oxolinic acid (24% of bacteria isolated from such ponds), followed by those that have previously used antimicrobials (19%) and the least was those from ponds that have not used any antimicrobials (17%). The lowest incidence of antibiotic resistance was observed in ponds that have not used any antimicrobials (41% of the isolates from such ponds). Among the individual antibiotics, incidence of resistance to oxytetracycline was highest (4.3% of the total number of isolates) followed by furazolidone (1.6%), oxolinic acid (1%) and chloramphenicol (0.66%).

Resistance to individual chemotherapeutants did not reflect the pattern of antimicrobial use with ponds that have previously used antimicrobials showing the highest incidence of resistance to one antimicrobial (12% of total isolates from such ponds). Resistance to both oxolinic acid and furazolidone (15% of total number of isolates) was highest compared to other antimicrobial resistance profiles (1–12%). Multiple antimicrobial resistance and intermediate reaction to at least one antimicrobial are associated with antimicrobial use.

Table 1
Antibiotic resistance profiles encountered

Resistance profile	Percentage occurrence in bacteria[a]			
	Ponds that did not use antimicrobial	Ponds that previouslys used antimicrobials	Ponds that are currently using an antimicrobial	Total
OTC, OXA, Fx, C	2	0	4	6
OTC, OXA, Fx	3	1	1	5
OTC, OXA, C	0	0	1	1
OXA, C, Fx	0	1	1	2
OTC, C, Fx	0	2	2	4
OTC, OXA	1	0	1	2
OTC, Fx	1	2	9	12
OTC, C	4	7	1	12
OXA, Fx	5	4	6	15
OXA, C	0	0	1	1
C, Fx	0	2	1	3

OTC = oxytetracycline, 30 μg/ml; Fx = furazolidone, 100 μg/ml; OXA = oxolinic acid, 2 μg/ml; C = chloramphenicol, 30 μg/ml.

[a](Number of isolates showing the same profile/total number of isolates from such ponds) × 100; rounded off to the nearest whole number.

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Integrated treatment of shrimp effluent by sedimentation, oyster filtration and macroalgal absorption: a laboratory scale study

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Abstract

Effluent water from shrimp ponds typically contains elevated concentrations of dissolved nutrients and suspended particulates compared to influent water. Attempts to improve effluent water quality using filter feeding bivalves and macroalgae to reduce nutrients have previously been hampered by the high concentration of clay particles typically found in untreated pond effluent. These particles inhibit feeding in bivalves and reduce photosynthesis in macroalgae by increasing effluent turbidity. In a small-scale laboratory study, the effectiveness of a three-stage effluent treatment system was investigated. In the first stage, reduction in particle concentration occurred through natural sedimentation. In the second stage, filtration by the Sydney rock oyster, *Saccostrea commercialis* (Iredale and Roughley), further reduced the concentration of suspended particulates, including inorganic particles, phytoplankton, bacteria, and their associated nutrients. In the final stage, the macroalga, *Gracilaria edulis* (Gmelin) Silva, absorbed dissolved nutrients. Pond effluent was collected from a commercial shrimp farm, taken to an indoor culture facility and was left to settle for 24 h. Subsamples of water were then transferred into laboratory tanks stocked with oysters and maintained for 24 h, and then transferred to tanks containing macroalgae for another 24 h. Total suspended solid (TSS), chlorophyll *a*, total nitrogen (N), total phosphorus (P), NH_4^+, NO_3^-, and PO_4^{3-}, and bacterial numbers were compared before and after each treatment at: 0 h (initial); 24 h (after sedimentation); 48 h (after oyster filtration); 72 h (after macroalgal absorption). The combined effect of the sequential treatments resulted in significant reductions in the concentrations of all parameters measured. High rates of nutrient regeneration were observed

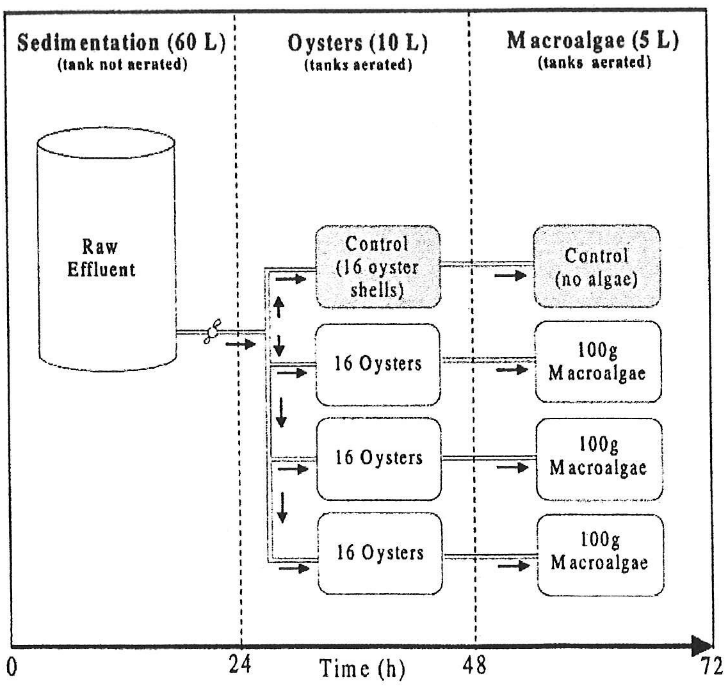


Fig. 1. Design of the integrated system for treatment of shrimp pond effluent and stocked with oysters (40 g *S. commercialis*) and macroalgae (*G. edulis*).

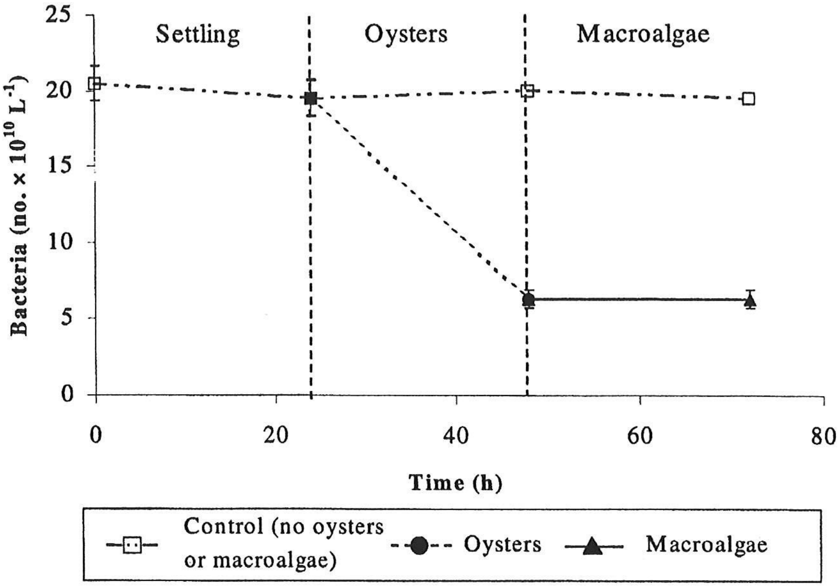


Fig. 5. Changes in bacterial numbers of shrimp pond effluent from sedimentation, oyster filtration and macroalgal absorption.

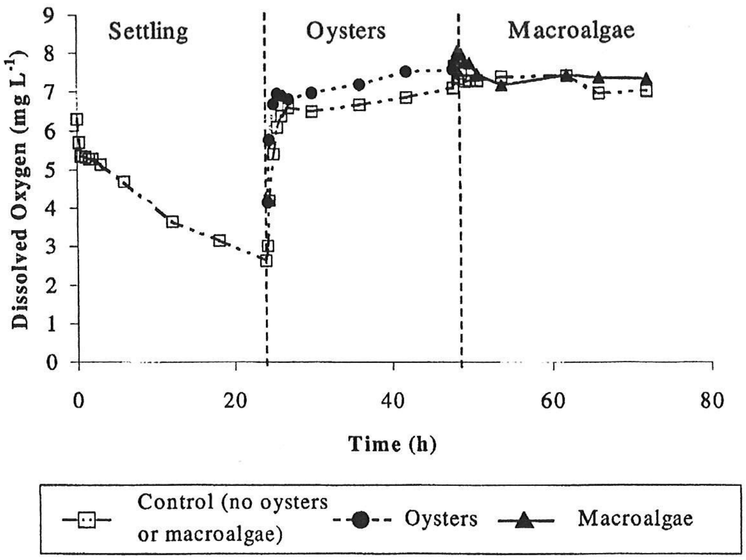


Fig. 6. Changes in water column dissolved oxygen concentrations of shrimp pond effluent from sedimentation, oyster filtration and macroalgal absorption. Standard error bars have been plotted, but are too small to be visible.

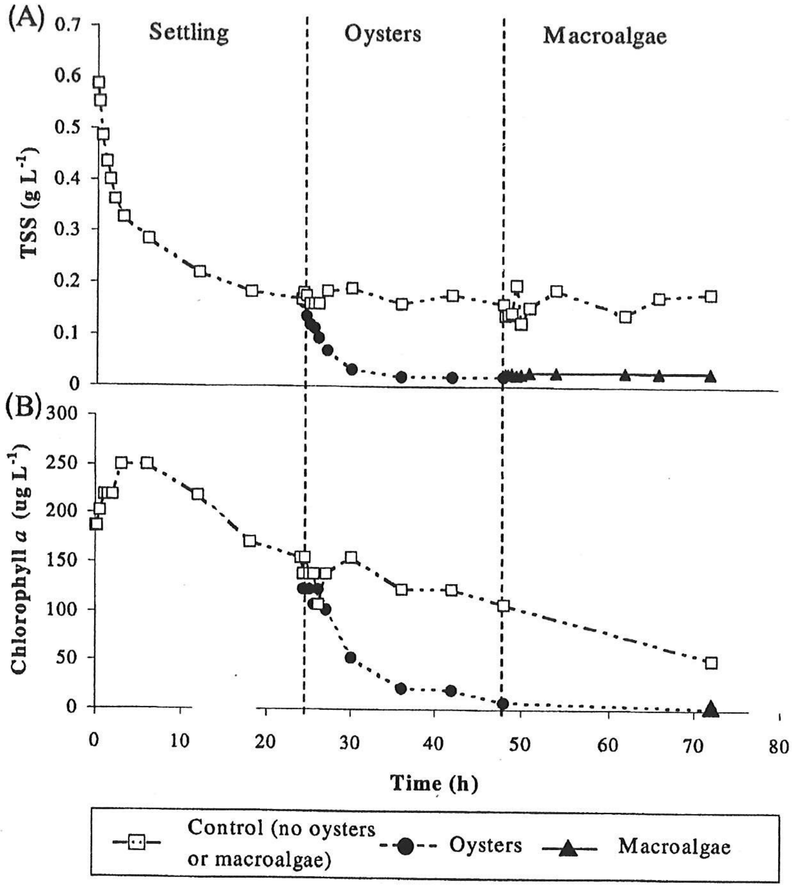


Fig. 2. Changes in total suspended solids (A) and phytoplankton biomass (chlorophyll *a*); (B) from sedimentation, oyster filtration and macroalgal absorption of shrimp pond effluent. Standard error bars have been plotted, but are too small to be visible.

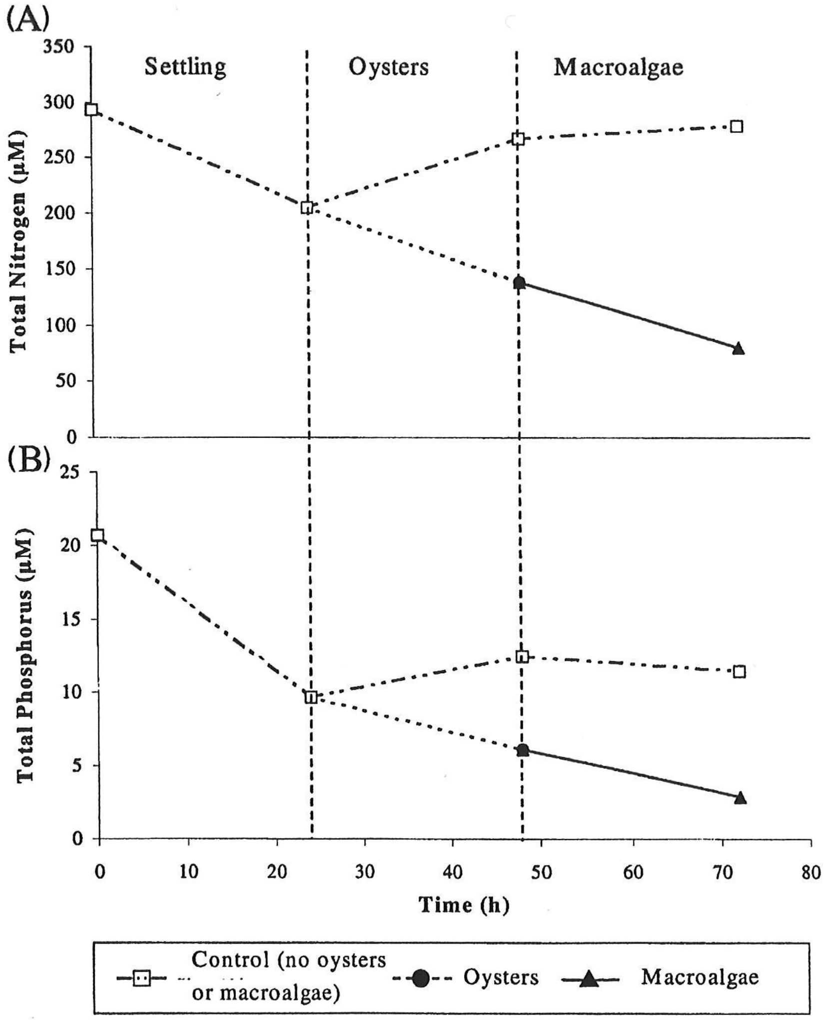


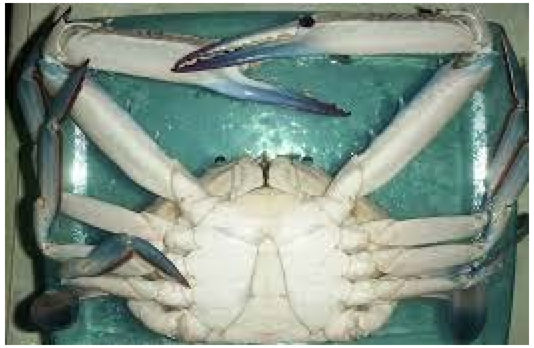
Fig. 7. Changes in water column total N (A) and P (B) concentrations of shrimp pond effluent from sedimentation, oyster filtration and macroalgal absorption. Standard error bars have been plotted, but are too small to be visible.

O. Decapoda – des plus primitifs aux plus récents

S-O. Astacidea

S-O. Anomura

Fam. Majidae

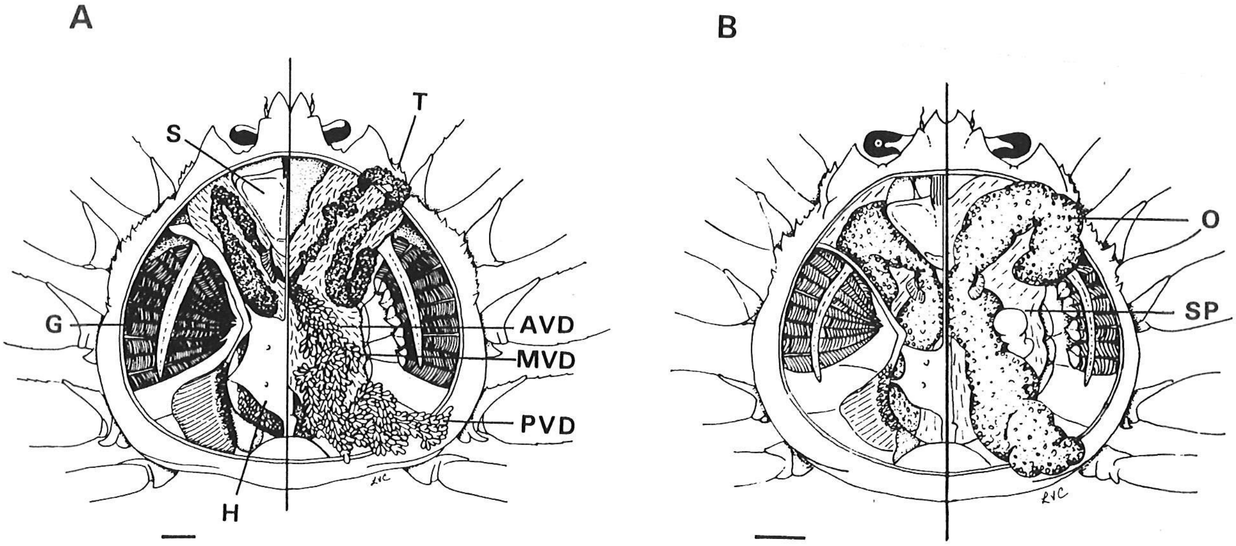


Fam. Portunidae

S-O. Brachyura

Chionoecetes opilio

La saison de reproduction



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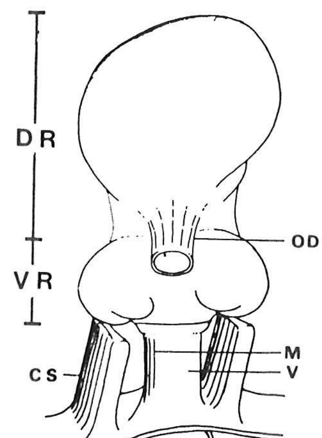

Journal of Shellfish Research, Vol. 14, No. 2, 365–370, 1995.

THE GONOPOD TEGUMENTAL GLANDS OF SNOW CRAB (*CHIONOECETES OPILIO*) ARE ACCESSORY REPRODUCTIVE GLANDS

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Shippagan, N.B. Canada

ABSTRACT To date, the role of the tegumental glands found in the first gonopod of brachyuran crabs has been a matter of conjecture. In order to more clearly understand the nature and ultimate function of these glands, histological and histochemical studies were performed on 17 male snow crabs, *Chionoecetes opilio* (O. Fabricius), captured in the Baie des Chaleurs, New Brunswick, Canada. Mature (M) and immature (IM) individuals were differentiated based on the carapace width (CW): cheliped height (CH) ratio. To assess the developmental trajectory of the glands, the immature crabs were subdivided into 3 groups, small immature (<40 mm CW), medium immature (40–70 mm CW), and large immature 70–100 mm CW). The precise distribution of the glands within the first gonopod was determined via serial sections (7–10 μm). The following histochemical tests were performed on the subsequently revealed glandular region of the first gonopod: Sudan black and Nile blue for lipids, orange G for aminated substances, alcian blue for acid mucopolysaccharides, and periodic acid-Schiff for neutral mucopolysaccharides (MPS). The volume fraction of the gonopod glandular region occupied by glands was assessed using stereologic counts.

The glands were determined to be of the rosette type, and restricted to a specific region at the base of the endopodite. Ducts leading from these glands to the cuticle of the ejaculatory canal only were clearly visible in medium immature to mature individuals; these ducts connected to pores in the cuticle. Cuticular pores and ducts were not observed in small immature crabs. The volume fraction of the glands increased in each successive maturity category, with a mean of 0.8% in small immature crabs and a mean of 8% in mature crabs. The glands contained either acid or neutral mucopolysaccharides, or a mixture of both. The pores of the ejaculatory canal contained similar secretions. These observations support the conclusion that the first gonopod tegumental glands in *C. opilio* are accessory sex glands.

KEY WORDS: *Chionoecetes*, reproduction, gonopod, tegumental gland

TABLE 2.

***Chionoecetes opilio*. Results of histochemical tests performed on gonopod tegumental glands.**

	Substances Tested			
Category	Lipids	Acid MPS	Neutral MPS	Aminated Substances
Mature	–	+ + +	+ +	+
Large immature	–	+ +	+ +	+
Medium immature	*	+ +	+ +	+
Small immature	*	+ +	+ +	+

–, negative; +, weakly positive; + +, positive; + + +, strongly positive; *, test not possible.

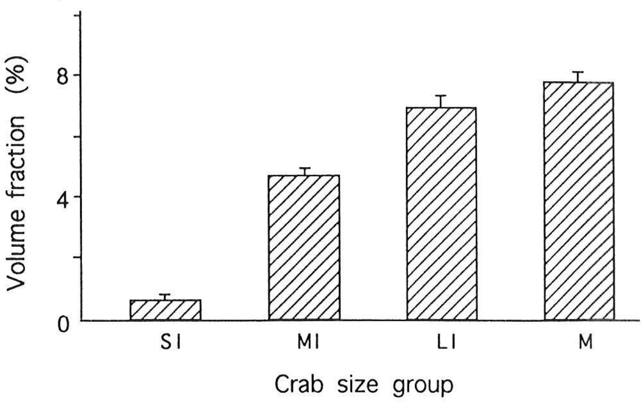

Figure 3. Volume fraction ($\bar{X}$ ± standard deviation) of tegumental glands within histological sections of gonopods of crabs from each size group. SI, small immature; MI, medium immature; LI large immature; M, mature.

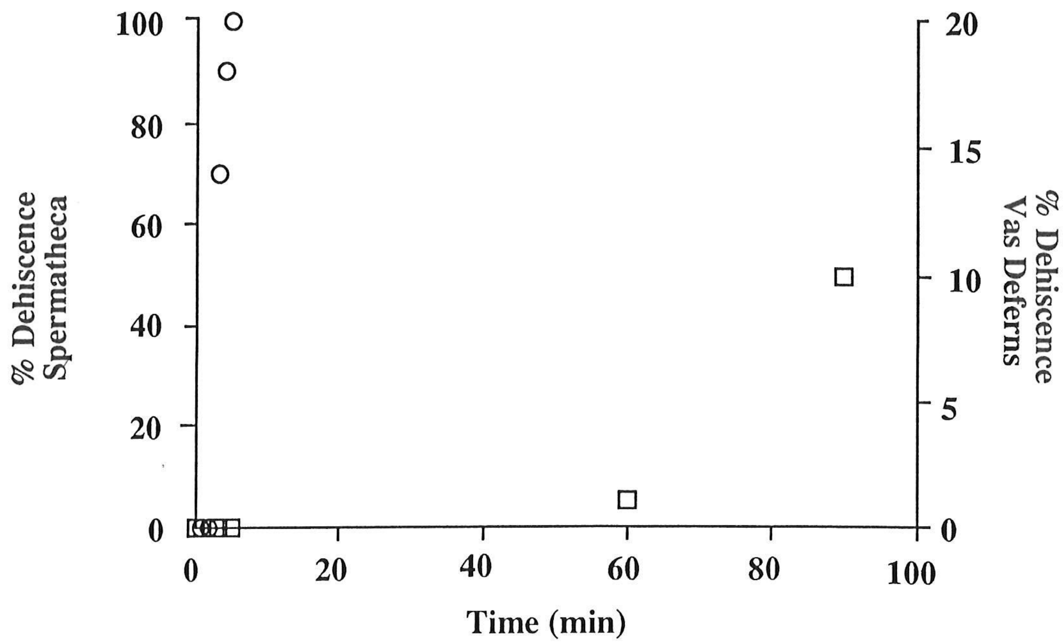

Fig. 6. Percentage of dehiscence versus time after contact with water of spermatophores from spermatheca (○) and posterior vas deferens (□).

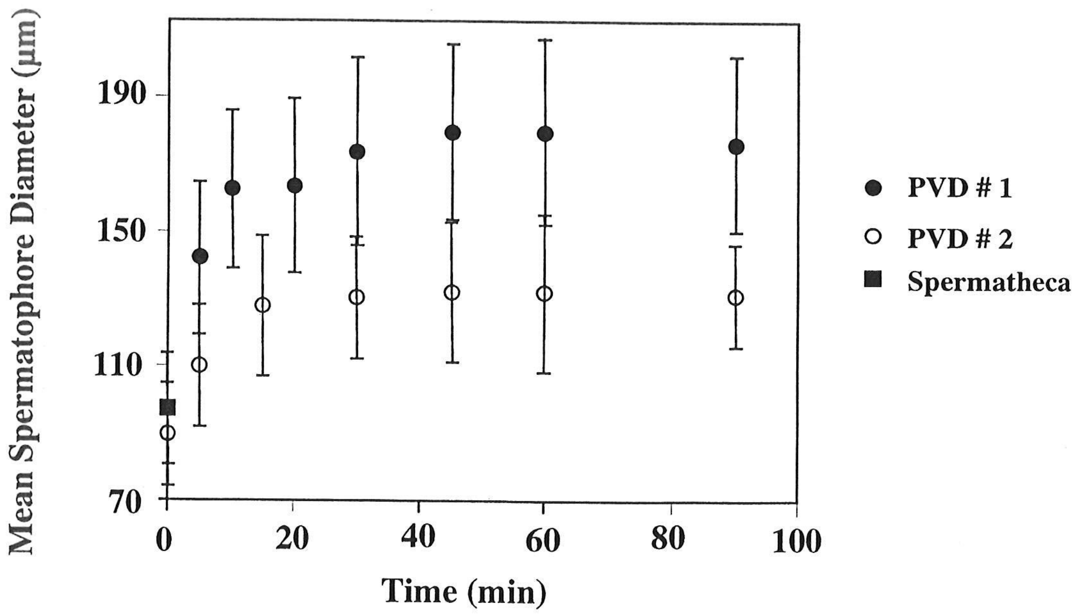

Fig. 7. Mean spermatophore diameter (±standard deviation) versus time after exposure to 0°C sea water for two trials from posterior vas deferens (PVD) and one trial from spermatheca. Initial size measured for PVD–2 and spermatheca trials before adding sea water. Size measurement for spermatophores from spermatheca not possible after addition of sea water, since dehiscence was extremely rapid.

Field comparison of survival and growth of hatchery-reared versus wild blue crabs, *Callinectes sapidus* Rathbun

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A B S T R A C T

The efficacy of restocking as a fisheries management tool depends upon the ability of hatchery-reared juveniles to survive, grow and reproduce in the wild following release. However, hatchery-reared animals may be maladapted to the natural environment as a result of morphological, physiological, or behavioral deficiencies acquired during the hatchery phase. To assess the competency of hatchery-reared blue crabs *Callinectes sapidus* Rathbun, a species under consideration for restocking in Chesapeake Bay, we compared survival and growth of hatchery-reared and wild juveniles using complementary field tethering experiments and small-scale field releases in shallow blue crab nursery habitats of the upper Chesapeake Bay. We observed no difference in the survival rates of hatchery-reared and wild crabs in either tethering experiments or paired field releases. Hatchery-reared and wild juveniles also exhibited similar growth rates and levels of growth variability. The results indicate that hatchery-reared juveniles are competent and likely not disadvantaged relative to wild conspecifics, and that poor performance of hatchery-reared individuals following release is not a significant barrier to restocking for this species in Chesapeake Bay. Further, our study highlights the potential utility of release experiments with hatchery-reared animals to provide key biological data for stock assessments and fishery management.

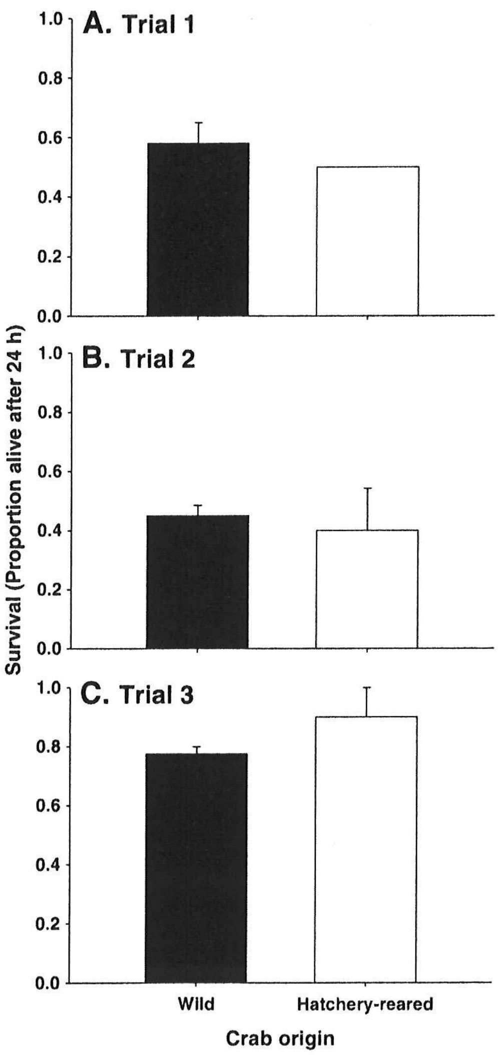


Fig. 2. Mean survival (±SE) of wild and hatchery-reared juvenile blue crabs in field tethering trials conducted in the summer of 2004 (A), fall of 2004 (B), and fall of 2009 (C).

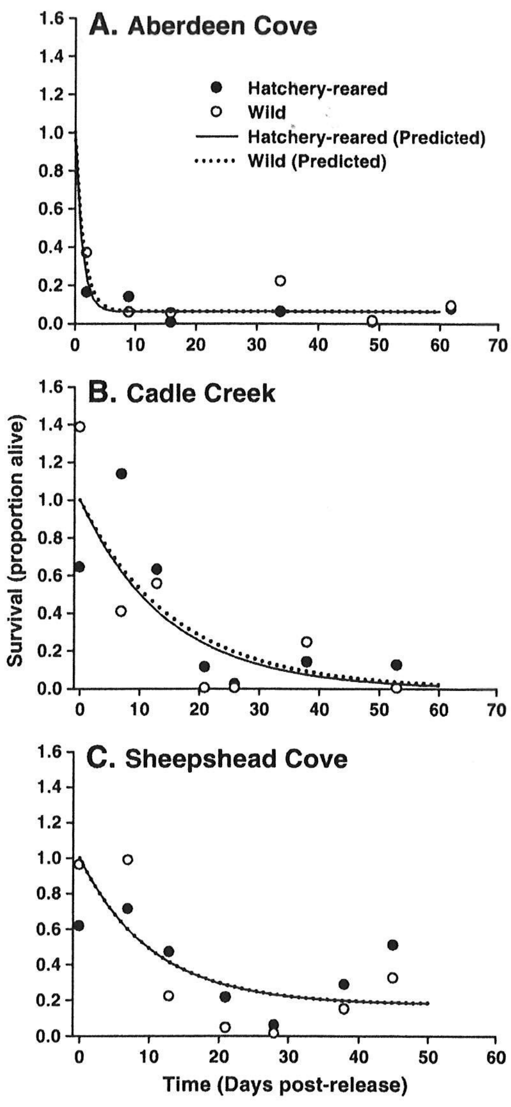
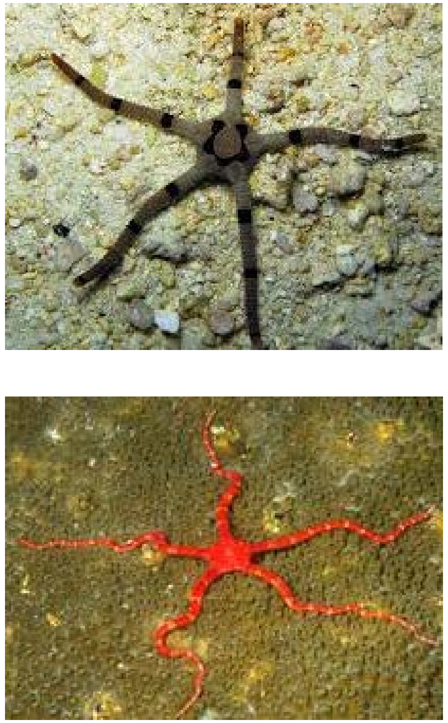


Fig. 3. Survival of wild (solid circles) and hatchery-reared (open circles) cohorts of juvenile blue crabs released simultaneously into three locations: Aberdeen Cove (A), Cadle Creek (B) and Sheepshead Cove (C) as a function of time (days post-release). Survival at time 0 is assumed to be 1, while all other points are estimated from field recapture data adjusted for gear efficiency, tag loss and area sampled (see text for details). Thus, it is possible for survival estimates to exceed 1. The best fit exponential decline model is shown for wild (solid line) and hatchery-reared (dashed line) cohorts for each release.

Echinodermata

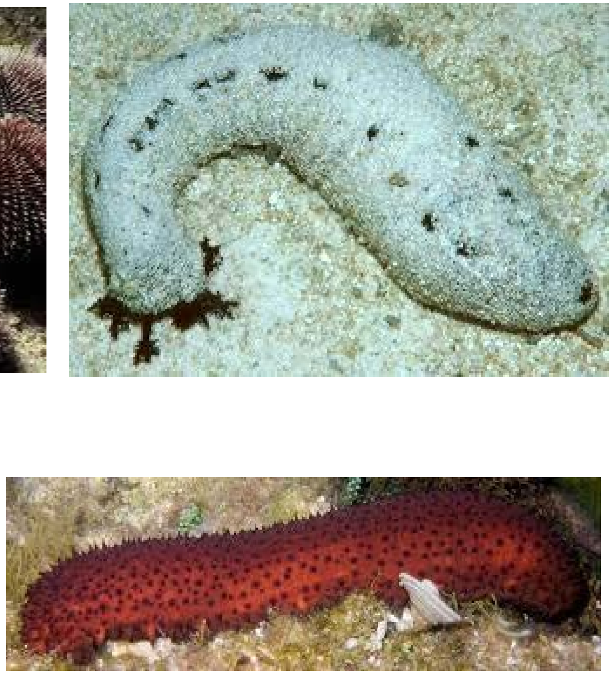
Crinoidea:
Crinoïdes et
Commatules



Ophiuroidea:
Ophiures

Asteroidea

Echinoidea:
Oursins réguliers
et irréguliers



Holothuroidea:
Concombres

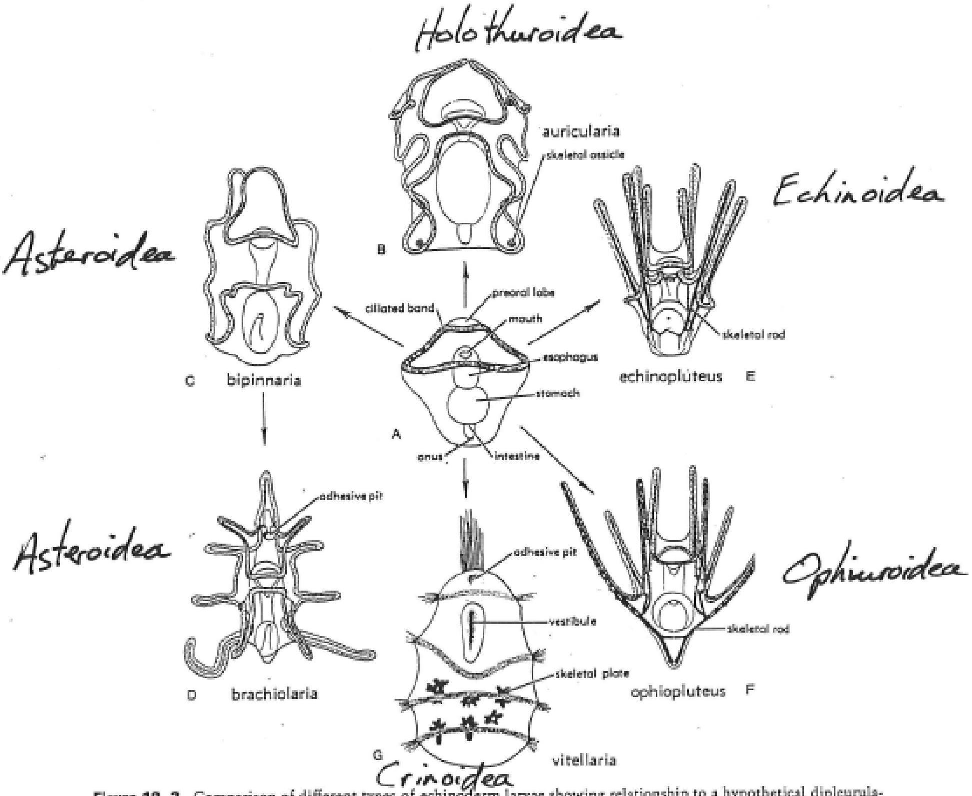


Figure 19–2 Comparison of different types of echinoderm larvae showing relationship to a hypothetical dipleurula-type ancestral larva. (From Ubaghs, G., 1967: *In* Moore, R. C. (Ed.): Treatise on Invertebrate Paleontology. Pt. S, Vol. 1. Courtesy of the Geological Society of America and the University of Kansas, Lawrence, Kan. pp. S3–S60.)

Oursins 1: Ressource fragile

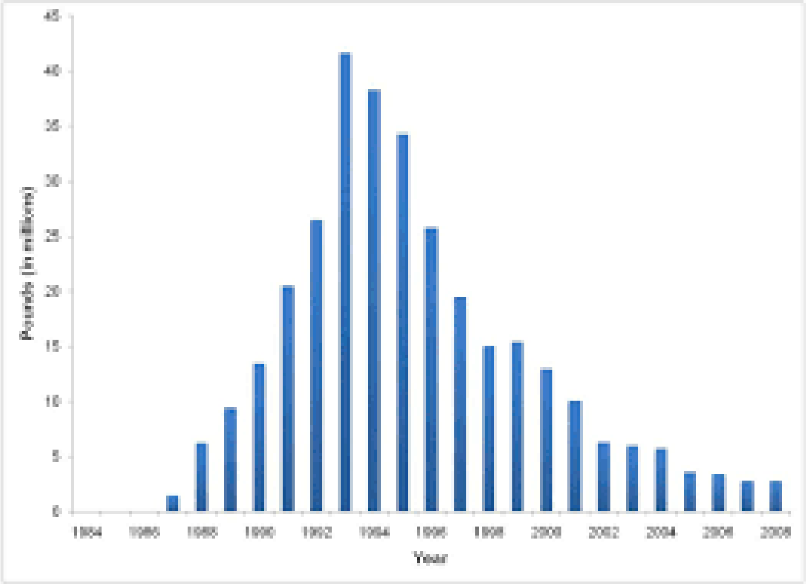
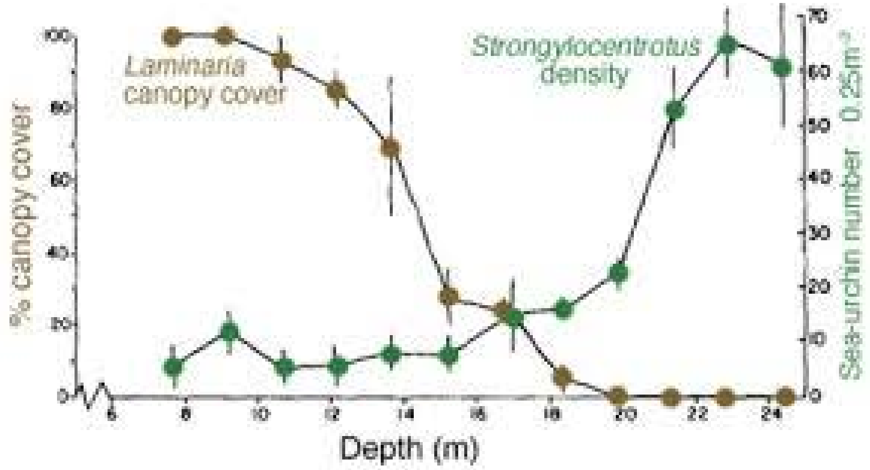


Figure 1.6 Changes in sea urchin harvest in the Gulf of Maine over time. The maximum harvest was 41.6 million pounds in 1993. The harvest has decreased each year since 1993. (Data source: DMR).

Oursins 2: le coupable idéal ?

Le méchant?



Le bon?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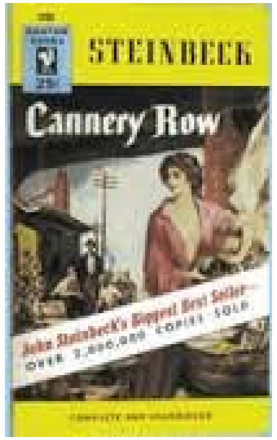
Oursins 3: Encore coupable?

Oursins 3 – les acteurs

Macrocystis spp. – abri pour poissons
– exploité



Clupea spp. – juvéniles dans *Macrocystis spp.*
– exploité

Strongylocentrotus purpuratus – mange *Macrocystis spp.*
– exploité

Enhydra lutris – mange *S. purpuratus*

- Intensivement chassé 1741 – 1911
- Protégé depuis

Marine Biology (2002) 140: 763–771
DOI 10.1007/s00227-001-0749-6

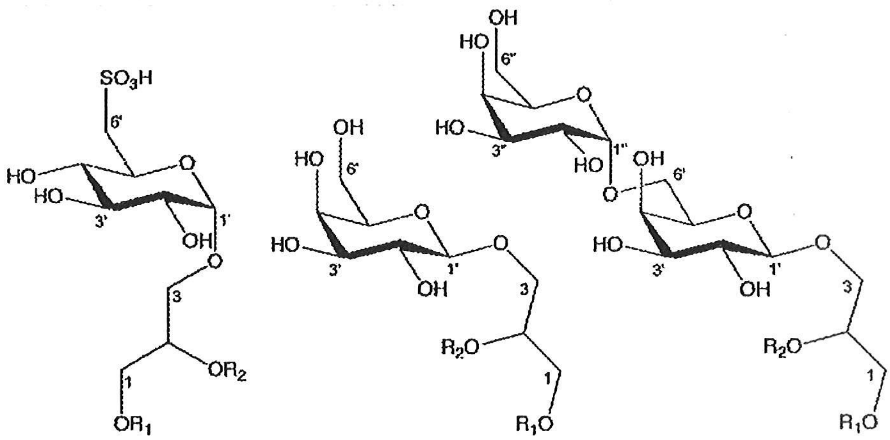
Y. Takahashi · K. Itoh
M. Ishii · M. Suzuki · Y. Itabashi

Induction of larval settlement and metamorphosis of the sea urchin *Strongylocentrotus intermedius* by glycoglycerolipids from the green alga *Ulvella lens*

Received: 8 February 2001 / Accepted: 26 October 2001 / Published online: 5 January 2002

Abstract In aquaculture centers of the northern region of Japan, "Nami-ita" (waved polycarbonate plates), on which the green alga *Ulvella lens* Crouan frat. (Chaetophoraceae: Chaetophorales) was cultured, are used to promote larval settlement and metamorphosis of the sea urchin species *Strongylocentrotus intermedius* (A. Agassiz) and *S. nudus* (A. Agassiz). We investigated chemical inducer(s) for larval settlement and metamorphosis of these sea urchins with extracts of *U. lens*. Bioassay-guided separation of the methanol extract using a combination of column and thin-layer chromatography led to the isolation of several active compounds, the chemical structures of which were determined by spectral and chemical methods. These active compounds were identified as glycoglycerolipids, all comprising several molecular species: sulfoquinovosyl monoacylglycerols (SQMGs), sulfoquinovosyl diacylglycerols (SQDGs), monogalactosyl monoacylglycerols (MGMGs), monogalactosyl diacylglycerols (MGDGs), digalactosyl monoacylglycerols (DGMGs) and digalactosyl diacylglycerols (DGDGs). Among these glycolipids, SQMGs, MGMGs, MGDGs and DGMGs induced larval metamorphosis of the sea urchin *S. intermedius*. SQMGs and MGDGs induced larval metamorphosis at a concentration of $5\ \mu g\ ml^{-1}$, whereas SQDGs and DGDGs only induced larval settlement. These glycoglycerolipids are new congeners of chemical inducers to settlement and metamorphosis of planktonic larvae of sea urchins. The findings would provide a better understanding of larval settlement and metamorphosis in sea urchins.

Fig. 3 *Ulvella lens*. Molecular structures of glycoglycerolipids, see "Methods" for unabbreviated names (*1* SQMGs; *2* SQDGs; *3* MGMGs; *4* MGDGs; *5* DGMGs; *6* DGDGs)



1: R_1 = acyl group, R_2 = H
2: R_1 = acyl group, R_2 = acyl group
3: R_1 = acyl group, R_2 = H
4: R_1 = acyl group, R_2 = acyl group
5: R_1 = acyl group, R_2 = H
6: R_1 = acyl group, R_2 = acyl group

ELSEVIER

Aquaculture 185 (2000) 85–99

Aquaculture

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Optimization of gonad growth by manipulation of temperature and photoperiod in cultivated sea urchins, *Paracentrotus lividus* (Lamarck) (Echinodermata)

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[b] *Centre régional d'études côtières, Université de Caen, Station marine, B.P. 49, F-14530 Luc-sur-Mer, France*

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Accepted 20 October 1999

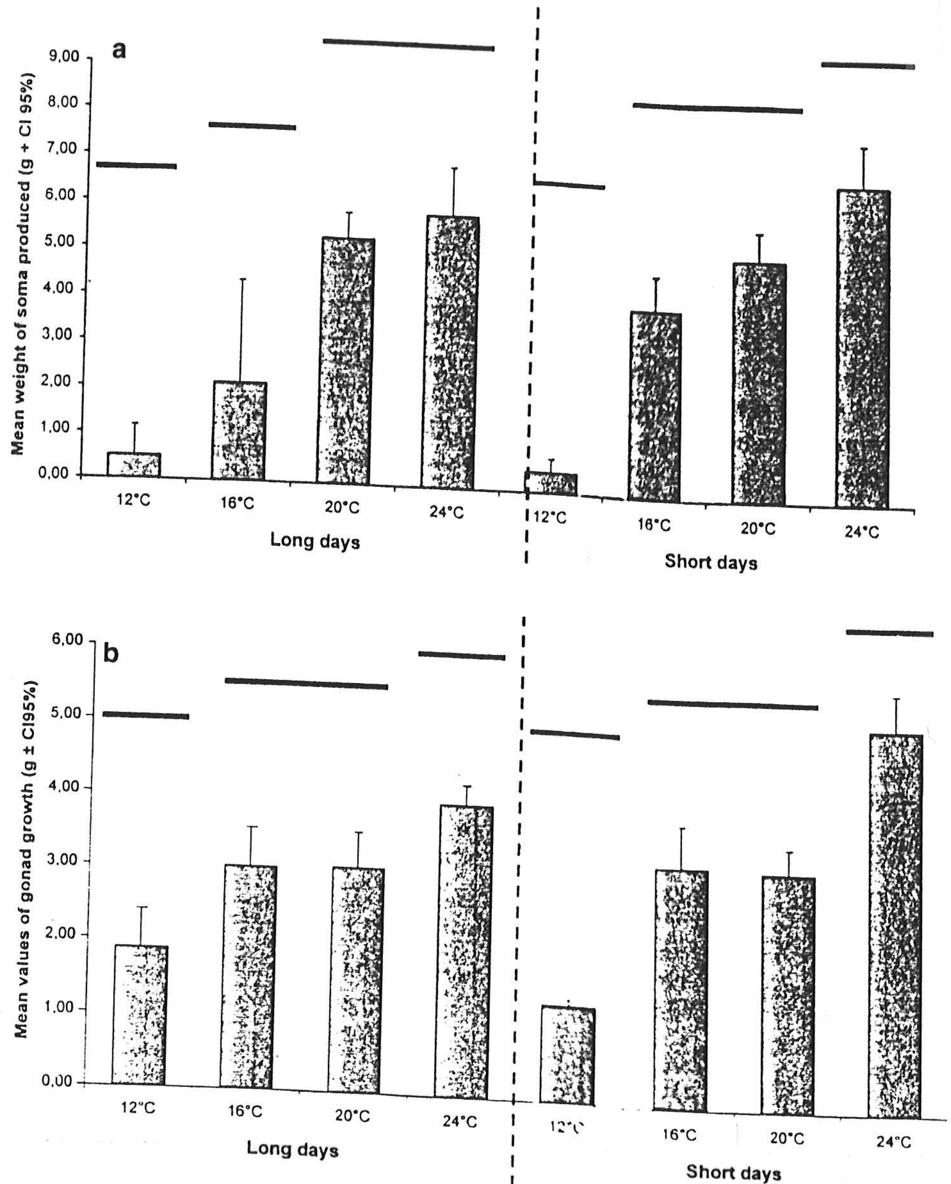

Fig. 3. *P. lividus*. Mean values of the (a) somatic production and (b) gonadal production vs. temperature and photoperiod. Bold horizontal lines at the same level mean no significant difference.

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Natural diets of lobster *Homarus americanus* from barren ground and macroalgal habitats off southwestern Nova Scotia, Canada

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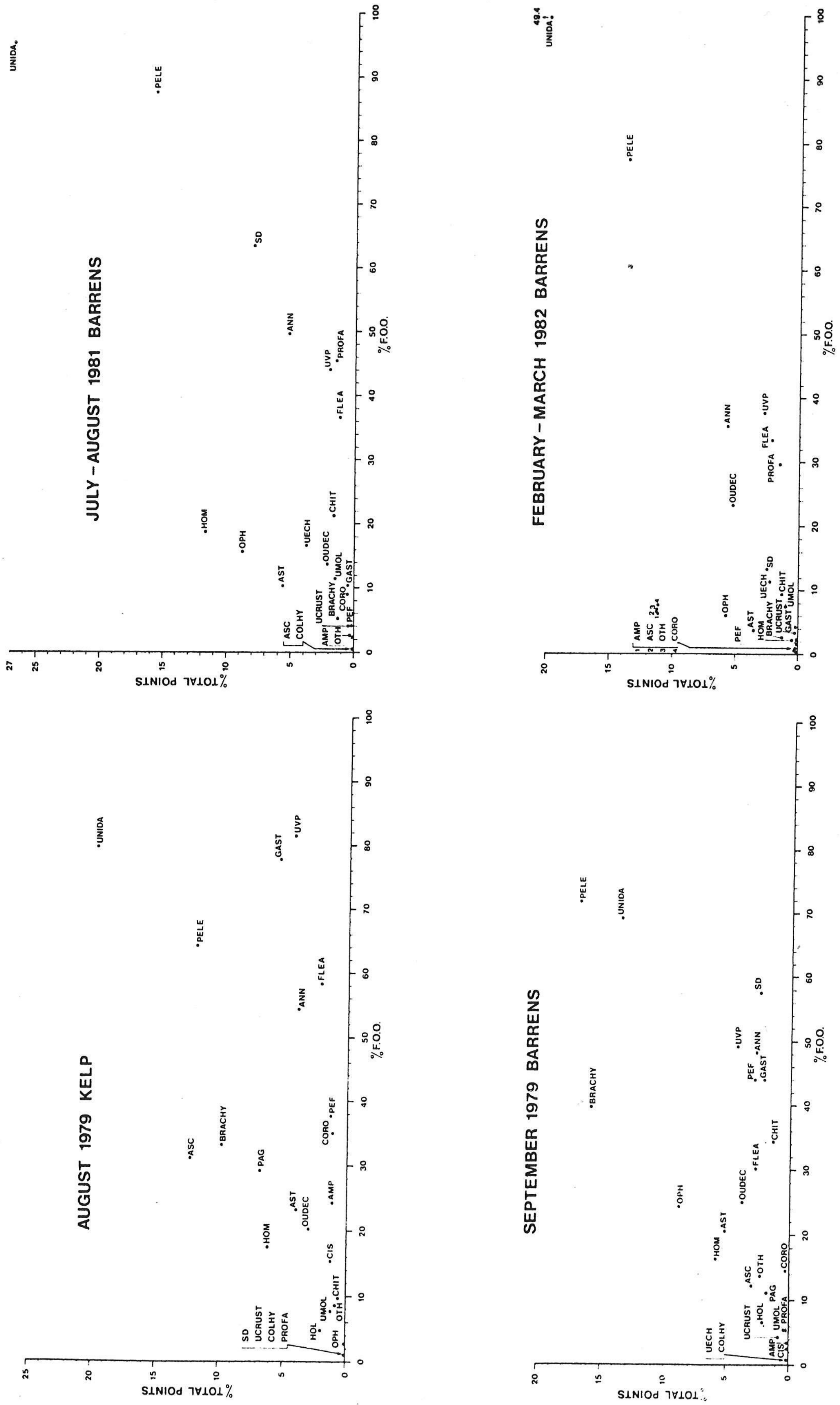
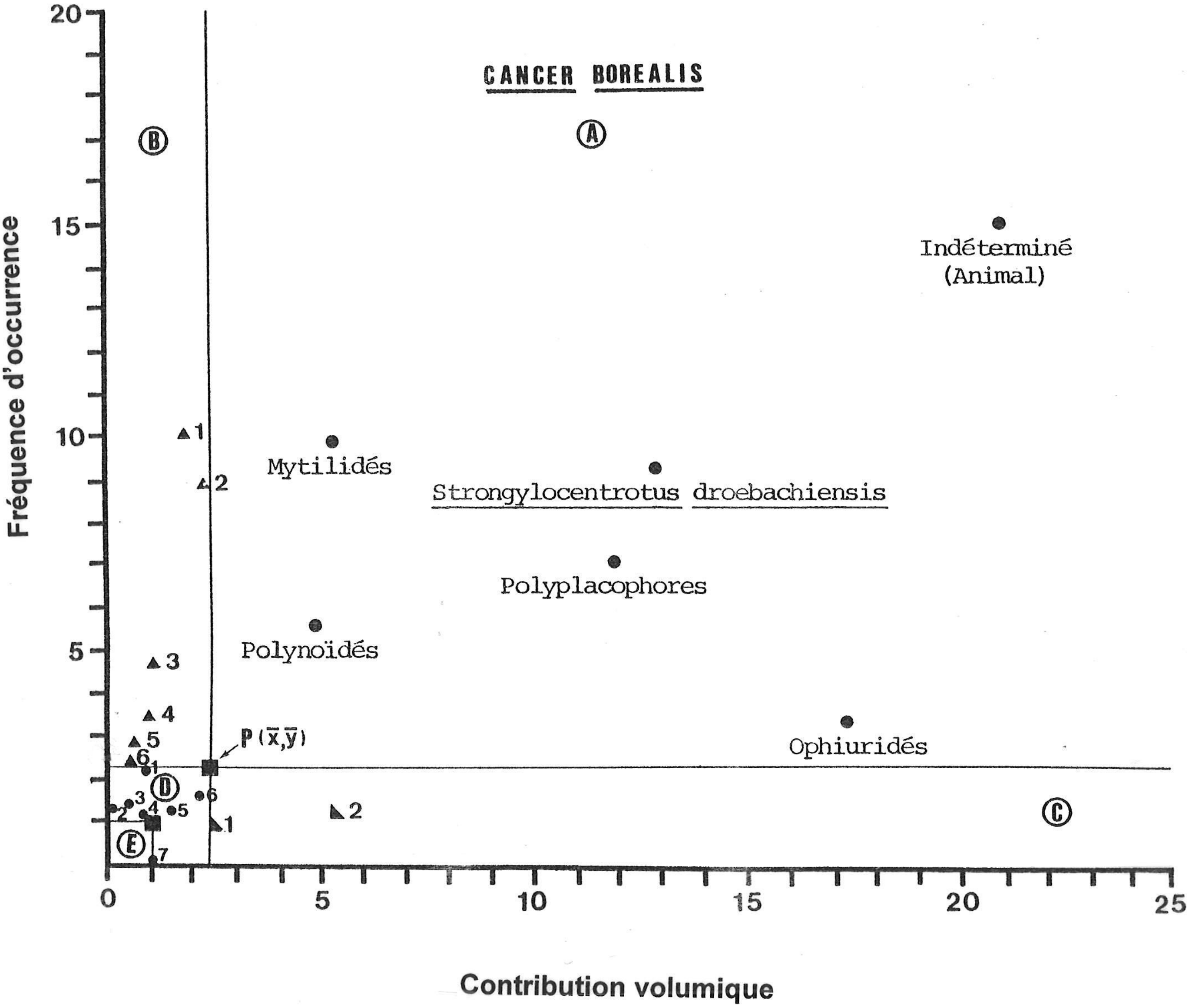


Fig. 2. *Homarus americanus*. Relative contribution of 26 diet categories in stomachs in terms of frequency-of-occurrence (F.O.O.) and points indexes (key to abbreviated forms in Table 3) for each of the 4 area-date groups

Table 6. Percentage frequency of occurrence of food items found in stomachs of snow crabs collected at East Arm, Outer Bay, South Arm, Wigwam Point, and Inner Bay. Sums of subcategories of food items do not always add up to the values of the major categories, since the latter also include unidentified components (unid. = unidentified).

Food type	Location				
	East Arm	Outer Bay	South Arm	Wigwam Point	Inner Bay
ANNELIDA	**32.0**	**40.5**	**12.6**	**40.3**	**34.8**
Sedentary burrowing, and tubicolous Polychaeta: *Sabella* sp., *Maldane* spp., *Pectinaria gouldii*, unid. Sabellidae, unid. Maldanidae	25.8	26.4	6.0	24.2	24.1
Errant surface dwelling Polychaeta: *Nereis* spp., *Harmothoe* sp., unid. Polynoidae	2.5	10.6	3.5	9.1	8.3
Errant burrowing Polychaeta: *Goniada maculata*, *Glycera* sp.	1.8	1.5	0.5	3.8	1.8
ECHINODERMATA	**31.2**	**17.4**	**0.8**	**10.5**	**15.2**
Ophiura spp.	29.6	13.2	0.8	10.5	15.2
Strongylocentrotus droebachiensis	0.0	2.5	0.0	0.0	0.0
Holothuroidea	1.6	1.7	0.0	0.0	0.0
MOLLUSCA	**22.4**	**16.4**	**3.3**	**20.9**	**18.2**
BIVALVIA: Nuculanidae, Cardiidae, Mytilidae, Mallayiidae, unid.	19.2	19.0	0.8	19.4	9.1
Small, thin shelled Bivalvia: *Nuculana tenuisulcata*, *Nucula* sp., *Crenella faba*, unid.	11.9	5.6	0.5	4.7	2.0
Yoldia spp.	2.5	5.2	0.3	4.3	4.0
Cerastoderma spp.	1.5	0.1	0.0	0.0	0.1
GASTROPODA: Buccinidae, Lacunidae, Trochidae, unid.	3.2	7.4	2.5	1.5	9.1
Small Gastropoda: *Lacuna* sp. *Margarites* sp., *Lora* sp., unid.	1.7	3.4	2.0	1.5	4.6
CRUSTACEA	**24.0**	**24.0**	**19.3**	**26.9**	**27.2**
Chionoecetes opilio	1.6	4.1	1.7	4.5	3.0
Hyas sp.	1.6	0.0	0.0	0.0	0.0
Natantia: *Pandalus borealis*, *Crangon septemspinosa*, *Sclerocrangon boreas*, unid.	11.2	5.0	7.6	13.4	18.2
Amphipoda: *Amphithoe rubricata*, *Byblis gaimardi*, *Anonyx liljeborgi*, *Anonyx* sp., unid.	0.8	5.0	4.2	4.5	1.5
Small Crustacea: Mysidaceae, Isopoda, Cumacea, Copepoda, Ostracoda, Pagurida, unid.	8.8	9.9	5.9	4.5	4.5
CNIDARIA	**0.8**	**24.8**	**0.8**	**13.4**	**21.2**
Colonial Hydrozoa: *Campanularia flexuosa*, *Campanularia* sp., *Halecium* sp., *Sertularella polyzonias*, unid.					
PORIFERA: *Clathrina* sp., *Myxilla* sp., unid.	**6.4**	**22.3**	**10.9**	**13.4**	**13.6**
Bryozoa (encrusting species)	**2.4**	**9.9**	**0.8**	**9.0**	**6.1**
Foraminifera: *Globigerina* sp.	**0.0**	**5.0**	**1.7**	**1.5**	**0.0**
Ostheichthyes: *Clupea harengus*, *Gadus morhua*, *Scomber scomber*, *Tautogolabrus adspersus*, *Mallotus villosus*, unid.	**24.8**	**38.8**	**23.5**	**50.7**	**34.8**
Plant material: Diatomea, *Chaetomorpha* sp., *Ptilota serrata*, unid.	**12.8**	**62.8**	**13.4**	**53.7**	**53.0**
"Nonfood": sediment, pieces of plastic, rubber and metal	**15.2**	**33.9**	**20.2**	**35.8**	**18.2**
Unidentified	**7.2**	**9.9**	**13.4**	**10.4**	**4.5**
Number of stomachs	125	121	119	67	66



CANCER BOREALIS
A
B
C
D
E
Indéterminé (Animal)
Mytilidés
Strongylocentrotus droebachiensis
Polyplacophores
Polynoïdés
Ophiuridés
P (x̄,ȳ)
Fréquence d'occurrence
Contribution volumique
0
5
10
15
20
25

Vol. 356: 295–298, 2008
doi: 10.3354/meps07238

MARINE ECOLOGY PROGRESS SERIES
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Published March 18

NOTE

Presence of the Jonah crab *Cancer borealis* significantly reduces kelp consumption by the green sea urchin *Strongylocentrotus droebachiensis*

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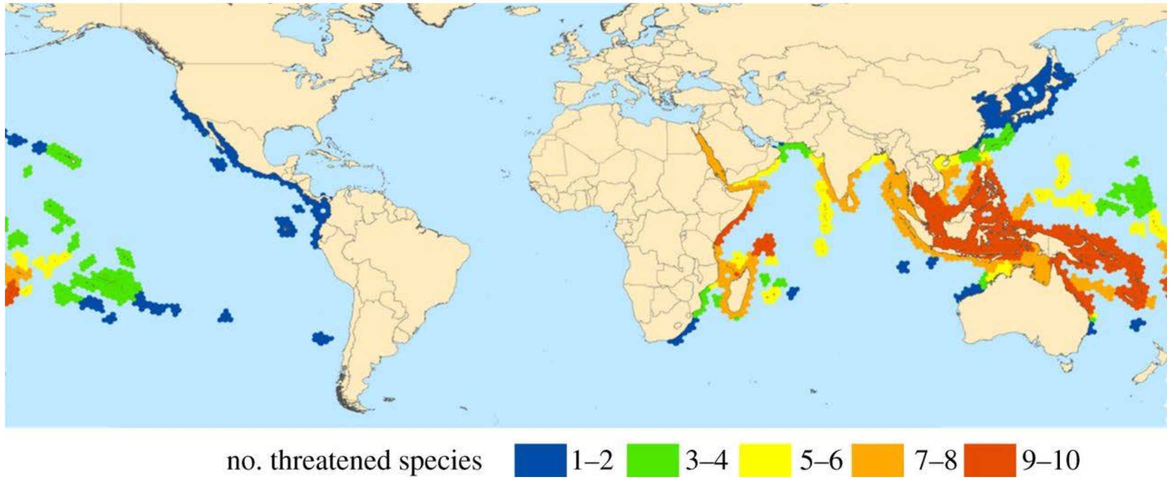
ABSTRACT: Predators can initiate trophic cascades by reducing densities of their prey, and such density-mediated interactions are well-known in marine environments. Growing amounts of evidence suggest, however, that predator-induced modifications in prey behavior and subsequent effects on lower trophic levels, or trait-mediated interactions, may also be of fundamental importance in marine systems. In laboratory experiments we found that green sea urchins *Strongylocentrotus droebachiensis*, herbivores whose feeding activities can cause shifts between kelp forests and urchin barrens, significantly decreased kelp grazing rates (on average by nearly 80%) in the presence of the echinivorous Jonah crab *Cancer borealis*. The Jonah crab and the green urchin co-occur across a wide geographic range and our results suggest that *C. borealis* has the potential to initiate a trophic cascade by controlling the behavior of urchins, which could have important positive effects on their kelp food resources.

Table 1. *Strongylocentrotus droebachiensis* influenced by *Cancer borealis*. Green sea urchin locations in experimental tanks at the middle (24 h) and end (48 h) of trials, and kelp (*Laminaria longicruris*) consumption at the end of the trials, in the presence/absence of the echinivorous Jonah crab. One urchin was dead at the end of the 48 h trial, but this was not attributed to a lethal crab effect

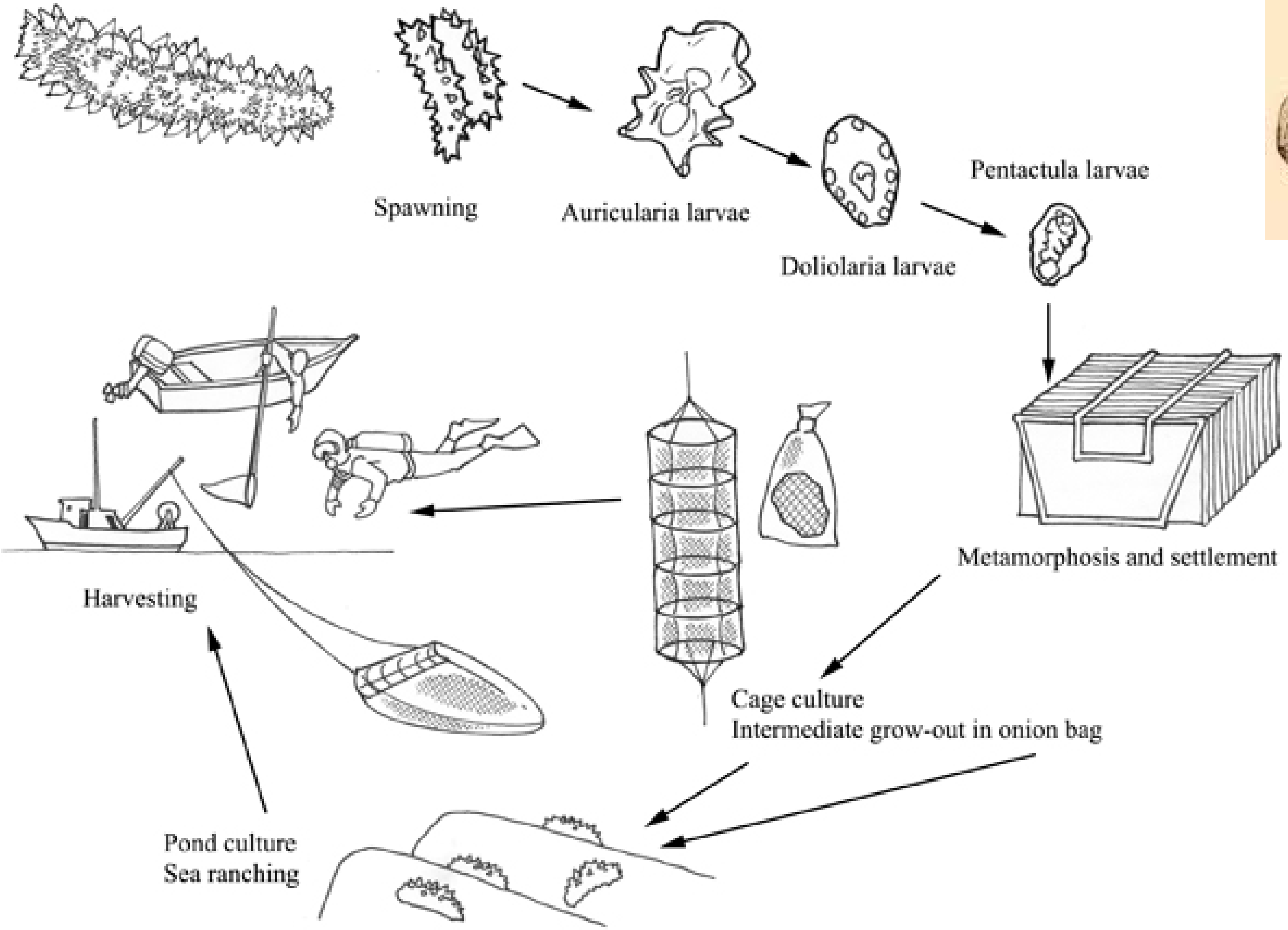
Treatment	Time (h)	Location (n)				Dead (n)	Consumption (g)
		Partition	Side wall	Far wall	Bottom		
Without crab	24	3	2	3	1	0	–
	48	2	4	1	2	0	0.85 ± 0.29
With crab	24	0	4	4	1	0	–
	48	0	4	4	0	1	0.16 ± 0.13

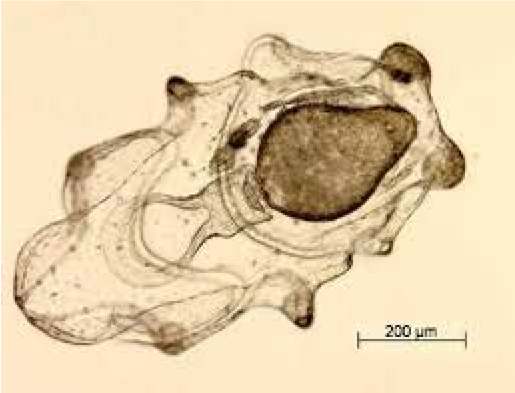
Classe Holothuria

La Pêche aux Holothuries



Holothuriculture





Ferme holothuricole au Madagascar

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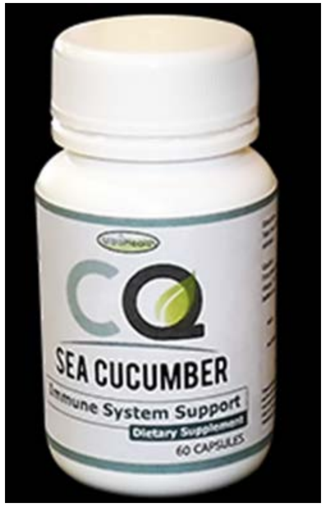

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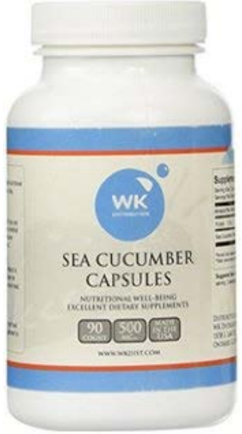
Stomach ulcers
Viruses



Marine Biology (2006) 148: 973–986
DOI 10.1007/s00227-005-0113-3

RESEARCH ARTICLE

Glenn R. Shiell · Sven Uthicke

Reproduction of the commercial sea cucumber *Holothuria whitmaei* [Holothuroidea: Aspidochirotida] in the Indian and Pacific Ocean regions of Australia

Received: 24 February 2005 / Accepted: 26 July 2005 / Published online: 24 September 2005

Abstract Seasonal trends in the gonad index (GI) of two widely separated populations of black teatfish, *Holothuria whitmaei* (formerly included in *Holothuria nobilis*), were investigated between Pacific (Great Barrier Reef) and Indian Ocean (Ningaloo Reef) coral reefs of Australia. Reproductive activity followed a similar annual trend, with the GI of both populations peaking typically between April and June. Macroscopic and histological analysis of Ningaloo Reef specimens revealed that large germinal tubules, positioned centrally on the gonad basis, progressed through four maturity stages: growing (II); mature (III); partly spawned (IV); and spent (V). Growing tubules dominated the central region of the gonad basis between January and March, followed by an increase in the number of mature tubules throughout the GI peak (April–June). The progressive appearance of partly spawned and spent tubules between June and October suggests that spawning in *H. whitmaei* continues intermittently over an extended period throughout the austral winter. The examination of the gonad structure of sexually mature male and female specimens identified five tubule size classes in total (C_1 to C_5), each of differing physical and gametogenic status. In females, smaller C_1 tubules located at the anterior edge of the gonad basis, contained pre- to early vitellogenic oocytes. Larger C_2 and C_3 tubule cohorts, positioned centrally on the gonad basis, contained mid- to late-stage vitellogenic oocytes. Smaller C_4 and C_5 tubules, located at the posterior edge, contained only relict oocytes. Similar physical and gametogenic differences were apparent between tubule cohorts in male specimens. We propose that these results, together with evidence of incomplete gonad resorption over the austral summer, indicate that gonad development in *H. whitmaei* conforms to the predictions of the Tubule Recruitment Model (TRM). The TRM is reported rarely among tropical aspidochirotes, and results presented here (1) provide the first direct evidence of this model in *H. whitmaei*, and (2) confirm that this species is one of the few winter-spawning tropical invertebrates.

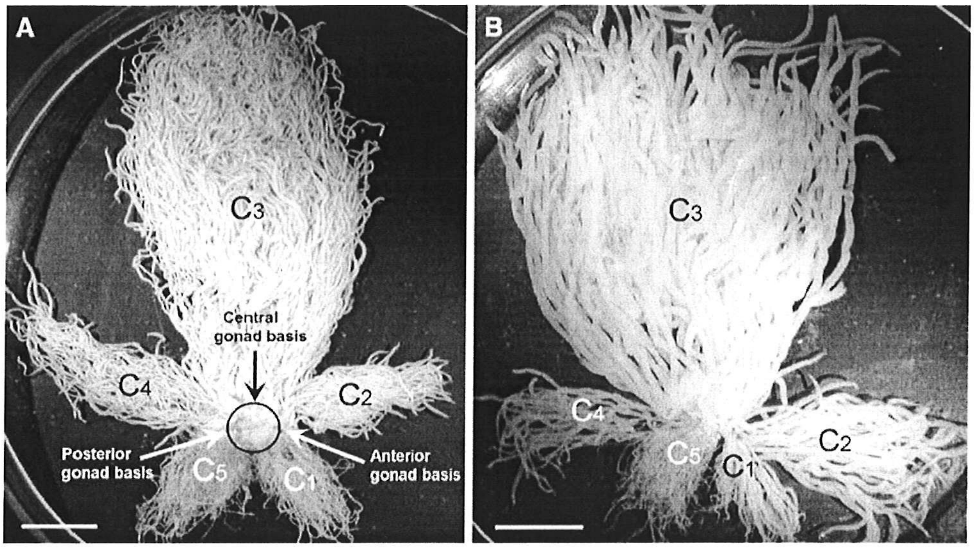


Fig. 5 *Holothuria whitmaei.* Typical arrangement of differing tubule cohorts, C_1–C_5, on sexually mature gonads of male (panel **a**) and female (panel **b**) specimens from NR, Western Australia. Tubules have been 'disentangled' to emphasise the physical characteristics of each size class and do not naturally occur as they appear in these photographs. (C_1) pre to early stages of oogenesis and spermatogenesis; (C_2) early to mid stages of oogenesis and spermatogenesis (male tubules contain both spermatocytes and spermatozoa); (C_3) mid to late stage vitellogenic oocytes and abundant spermatozoa; (C_4) partially spawned stage (reduced numbers of oocytes and spermatozoa—some reinitiation of gametogenesis in both males and females); (C_5) spent stage tubules contain only relict oocytes and sperm and are markedly pigmented (rust/brown). C_5 tubules also contain many nutritive phagocytes. Stages of maturity progressively increased in an anti-clockwise direction from C_1 to C_5. The *circled* section in panel **a** depicts the various regions of the gonad basis (anterior, central and posterior) used to define tubule cohorts. Histology images for each of the tubule cohorts are presented in Figs. 7 and 8. *Scale bars* in (**a**) and (**b**) = 15 mm

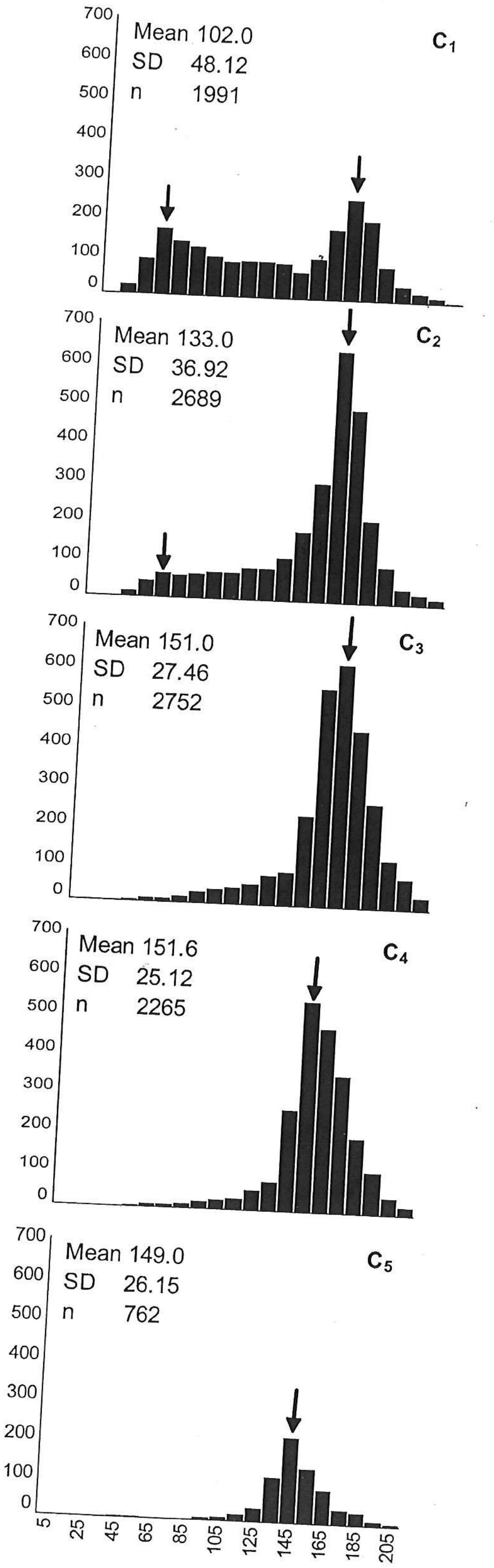


Fig. 6 *Holothuria whitmaei*. Length-frequency distribution of oocytes within each of the tubule cohorts (C_1–C_5) identified in sexually mature female specimens (combined data for the 6 specimens obtained in May 2002). *Arrows* (∃) indicate modes in the data