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Abstracts, publications, workshops & meetings

*Bohadschia argus*

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Abstracts on holothurians compiled by C. Conand

1. Holothurian fisheries

Stock assessment of the commercial sea cucumber *Parastichopus californicus* in the San Juan Islands, Washington State, USA

by A. Bradbury¹, W. Palsson² & R. Pacunski²

¹ Washington Department of Fish and Wildlife, Point Whitney Shellfish Laboratory, 1000 Point Whitney Road, Brinnon, WA 98320, USA

² Washington Department of Fish and Wildlife, Olympia, WA, USA

Although the sea cucumber *Parastichopus californicus* has been commercially exploited in the eastern Pacific since the 1970s, stock assessment has been hampered by a lack of life history data typically used in age- or size-structured models. Likewise, the lack of a long time series of catch-effort data reflecting 'equilibrium' conditions has precluded the use of many classic surplus production models. We present a simple surplus production model for *Parastichopus* which relies on a time series of catch and biomass estimates in the San Juan Islands. Harvestable biomass was estimated in two consecutive years with an underwater video method, systematically sampling along the shoreline at depths up to 40 m. Additional biomass estimates were made using dive survey data and a Leslie declining catch-per-effort technique. An independent dive survey biomass estimate which related observed declines in sea cucumber density to known catch came within 10 per cent of the corresponding video estimate. We fit a Schaefer surplus production model to these biomass estimates and the known catch during a 5-year period. Model predictions of maximum sustainable yield (MSY) ranged from 12–35 per cent of the unfished biomass per year. The best fits using video data estimated MSY between 12–14 per cent of the unfished biomass. We suggest a cautious application of these harvest rates, due in part to the relatively low precision of the video density estimates (CVs 30%). In future surveys, our results suggest that more efficient substrate-based stratification and increased sample size may improve precision, and that validation of video counts by divers may reduce bias. Despite these limitations, video has advantages over traditional dive surveys, including safety, increased depth range, economy, increased sample size, and the ability to survey several species simultaneously.

Review of recent developments in the Baja California, Mexico, *Isostichopus fuscus*, *Holothuria impatiens*, and *Parastichopus parvimensis* fisheries

by L.R.S. Castro, Semarnap-Inp, B.C., Mexico

Along the Pacific coast of Mexico, only Baja has a permanent holothurian fishery producing the highest catches, and also has a program for its study. Exploitation started in 1988 with *I. fuscus* (subtropical), in 1989 with *P. parvimensis* (temperate) and in 1994 with *H. impatiens* (subtropical). The annual catches (metric tonnes live weight) for both coasts through 1988–1996, east-west are: 730–, 553–57, 568–470, 1038–553, 960–613, 465–450, 479–727, 203–734,

40–160. Although a small fishery, it is economically significant, being one of the few sources for jobs on the east side. In the west, it helps economic survival during closure of the more profitable red sea urchin season and complements profits from abalone, top shell and keyhole limpet harvests. Holothurian exports include gutted dried whole, boiled semi-frozen skin, raw fresh muscle, and gutted whole in brine. Yields are 4–6%, 12%, 7–12% and 15% respectively. Prices are variable, influenced by devaluation, introduction of Central American markets and organisations of international traders. Our studies started in 1990 and became systematic in 1994. Drops in CPUE from 2000 kg/diver/boat to 150 kg along with drastic increases in number of permits, actual dive depth above 20 m and absence of virgin stocks below 20 m indicates overfishing. After 1990, yield fluctuations are probably stock-related. Understanding of population growth and stock size is poor, but we suggest an arbitrary quota of 500 t and closure of some areas to assure spawning stock for recruitment. The reproductive cycle shows latitudinal differences: *Parastichopus* spawns in late spring in the north and in the summer further south. Four-month seasonal closures are needed: September – December in the east, April – July in the west. Diving surveys of randomly drawn quadrats show these densities (per m²): east, 1990–1.46, 1991–0.38, 1992–0.09, 1993–0.14, 1996–0.075 and 0.08 for *H. impatiens*; west, 1996–0.03. This spring, submarine video was also taken. Correlation indices of total and gutted-drained measures and size frequency distributions are presented.

Overexploitation in the present world sea cucumber fisheries and perspectives in mariculture

by C. Conand

Laboratoire d'écologie marine, Univ. La Réunion, France

Holothurians are traditionally fished for human consumption in many tropical and temperate Pacific countries. Despite their very long-standing history, they are presently overexploited in most countries. Western Atlantic fisheries, both temperate and tropical, are generally more recent. Following the last review by Conand and Byrne (1993), the present trends are analysed from catches and trade statistics. A few case studies are also presented from recent experiences in tropical islands and mainland countries (Indonesia, New Caledonia, Madagascar, etc.). They show that during recent years, signs of overexploitation have increased, in relation to the present high commercial value of this product. The frequency of the conflicts for resource use, both at national level and between nations, is also increasing. It is probably the right time to draw attention at the international level (international organisations, conservation agencies), to those species whose taxonomy, biology and ecology are still poorly known. Mariculture projects for stock enhancement and/or for growth, are being conducted in several countries. They show promise, but the circulation of the information concerning their results is still very limited and scattered, and should be encouraged.

A review of the status of echinoderm fisheries in Australia and New Zealand

by J. Keesing¹, S. Uthicke², P. McShane³, N. Andrew⁴, W. Zacharin⁵, H. Gorfine⁶, M. Alma⁷, D. Ramm⁸ & L. Joll⁹

¹ South Australian Research and Development Institute, Adelaide, Australia

² Australian Institute of Marine Science, Townsville, Australia

³ National Institute of Water and Atmospheric Research, Wellington, New Zealand

⁴ New South Wales Fisheries Research Institute, Cronulla, Australia

⁵ Tasmanian Department of Primary Industries and Fisheries, Hobart, Australia

⁶ Victorian Fisheries Research Institute, Queenscliff, Australia

⁷ Queensland Fish Management Authority, Brisbane, Australia

⁸ Northern Territory Department of Primary Industries, Darwin, Australia

⁹ Western Australian Department of Fisheries, Perth, Australia

Echinoderm fisheries are a small component of total fisheries production in both Australia and New Zealand and a small component of the world's echinoderm fisheries. Echinoderm fisheries are segregated largely on a temperate and tropical basis, with sea urchins fished in southern states of Australia and in New Zealand and holothurians in the tropical waters of northern Australia. Holothurians are an insignificant catch in temperate waters, although there is an exploratory interest in *Stichopus mollis* in New Zealand and some southern Australian states. Sea urchins are generally regarded as being under-exploited in both Australia and New Zealand with low value and variable quality inhibiting fishery development. There is some interest in post-harvest conditioning to improve quality in both Australia and New Zealand. Sea urchin species exploited are

Heliocidaris erythrogramma, *H. uberculata* and *Centrostephanus rodgersii* in southern Australia, and *Evichinus chloroticus* in New Zealand. Holothurian species fished commercially in Australia are principally *Holothuria scabra*, *Holothuria nobilis* and *Thelenota ananas*. *Holothuria atra*, *Holothuria fuscogilva* and *Actinopyga echinites* are also collected. There has been substantial recent interest in the beche-de-mer fishery in Queensland, Western Australia and the Northern Territory and rapid expansion in Queensland in particular with concerns of over-exploitation of stocks in the Torres Straits. This paper presents a summary of catch and value statistics for echinoderm fisheries in each Australian state and New Zealand along with an assessment of the current status of fisheries, management arrangements and the likely factors affecting future development of the fisheries.

Response of sea cucumber populations to a conservative harvest strategy in southeast Alaska, USA

By D.A. Woodby¹ & R.C. Larson²

¹ Alaska Department of Fish and Game, Douglas, Alaska, USA

² Alaska Department of Fish and Game, Petersburg, Alaska, USA

Sea cucumber (*Parastichopus californicus*) populations have shown mixed responses to conservative management in Southeast Alaska in the past six years. The Alaska Department of Fish and Game has conducted a very conservative fishery since 1990 with harvest rates of about 5 per cent per year. All local populations are surveyed prior to fisheries conducted on a three-year rotational basis. Of 28 local populations that have been surveyed at least twice, only 4 have had significant changes in densities. Survey biomass data indicate that several areas have had marked decreases in average mass but stable or slightly increasing densities, suggesting recruitment events into the fishery. Given the highly conservative nature of the management programme in Southeast Alaska, these results have implications for sustainable sea cucumber fisheries in general.

Population and reproductive biology of the sea cucumber *Isostichopus fuscus* in the Galapagos Islands

by P.C. Martinez, M.V. Toral, & R.H. Bustamante

Charles Darwin Research Station, Santa Cruz, Galapagos, Ecuador.

The commercial exploitation of the sea cucumber *Isostichopus fuscus* in the Galapagos Islands, and the lack of studies of its ecology and reproductive biology, created the need for a long-term study to understand and manage this species. Between 1993 and 1996, six censuses were completed in seven sites of the Bolivar Channel (between the Isabela and Fernandina islands). Twenty-five to thirty individuals were collected monthly from the Fernandina and Santa Cruz islands to determine their reproductive timing. The population density around Fernandina decreased more than 50 per cent from the original census in 1993. The size structure of the population was relatively stable, with lengths from 8 to 35 cm and no smaller size classes were found. The minimum length and drained weight of individuals with mature gonads was 16 cm and 150 g. The peaks of reproductive maturity were found from November to March. The absence of juveniles in the study sites suggests different habitat preferences between juveniles and adults. Censuses demonstrated that population density levels are declining and that present levels will not allow sustainable fisheries in this area. This study will provide baseline data for the conservation and management of *I. fuscus* in the Galapagos.

Resource evaluation of the sea cucumber (*Stichopus mollis*) in an environmentally sensitive region of New Zealand

By P.V. Mladenov & P. Gerring¹

Department of Marine Science, University of Otago, PO Box 56, Dunedin, New Zealand

¹ Present address: National Institute of Water and Atmospheric Research, P.O. Box 14-901, Kilbirnie, Wellington, New Zealand

A number of companies have located overseas markets for products derived from the New Zealand sea cucumber, *Stichopus mollis*. In late 1990, one company was granted a special permit to harvest by SCUBA up to 74 t green weight of *S. mollis* from the fiords of south eastern New Zealand to evaluate the potential of this fishery. This

proved to be a controversial initiative because it was not preceded by a resource assessment, and because the fiords are unique marine habitats surrounded by pristine catchments comprising a national park and world heritage area. In this paper we present the results of a resource evaluation conducted in four of the fiords during the course of the experimental harvesting operation. *S. mollis* was found on a great variety of substrata and was uniformly distributed throughout the fiords (but avoided the low salinity surface layer when present) at densities in the range of 1–2 individuals/10 m².

Mean catch per unit effort (CPUE) for this virgin stock was about 52 kg/diver-hour (SD=18) which equates to about 1 kg, (or four animals), per minute. Crude projections of green weight biomass, in depths of 0–20 m, ranged from 860 kg/km of coastline in Doubtful Sound to over 2000 kg/km of coastline in Charles Sound (mean of 1574 kg/km of coastline for the four fiords surveyed). On this basis, the total projected biomass in the all of the fiords approximates 1950 t in the 0–20 m strip surveyed. Potential impacts of such a fishery in the fiords include incidental damage to other organisms, particularly black coral, which is a protected species, and alteration of energy flow, particularly along detrital pathways.

Growth and reproduction of the commercial sea cucumber *Parastichopus parvimensis* in Baja California, Mexico

by G. Pérez-Plascencia

Abulones cultivados, A.P. 570, Ensenada, B.C Mexico

The somatic growth and reproductive cycle of the commercially exploited sea cucumber *P. parvimensis* were analysed. The individuals were collected monthly between June 1993 and December 1994 at Todos Santos Islands (Baja California, Mexico), 15 m deep; transported to the lab in plastic bags in sea water with menthol crystals to relax them. Biometrical analysis was performed on: total length; total drained wet weight; body wall wet weight; length and weight of the digestive tract; gonad wet weight and external diameter of the calcareous crown. The average length was 23.2 ± 6.2 cm; total wet weight 147.8 ± 82.3 g, and gutted drained wet weight 125.6 ± 66.0 g. The calcareous ring was not adequate for measuring. *Parastichopus parvimensis* seems to be dioecious and iteroparous, with annual synchronic reproductive cycle reaching its maximum gonad index in April, for both male and females. Size at maturity was 160 g approximately (body wall wet weight), with no external sexual dimorphism. *P. parvimensis* showed a progressive atrophy of the visceral organs, with a complete disappearance by the end of October, thus getting into a cryptic habitat and hiding in holes and crevices. During this period, the body wall weight was reduced about 30 per cent. The gradual recovery of the digestive tract was completed within the next 2–4 weeks. In December the sea cucumbers showed themselves again and formation of gonads began, which (after the reproductive event) were gradually absorbed, and sea cucumbers remained sexually undetermined until the end of the year. A recruitment was observed between June and July. Two years of growth, referred to the wet weight of the body wall, were reconstructed and parameters of the von Bertalanffy growth function, with the inclusion of an oscillatory element, were obtained. It is important to point out that in the study area since 1991, *P. parvimensis* has been intensely harvested and populations around the islands seriously depleted.

Sea cucumber fisheries in Venezuela

by E. Rodriguez and S. Marques Pauls

Instituto de Zoología Tropical, Facultad de Ciencias, Universidad Central de Venezuela, Apartado 47058, Caracas 1041-A, Venezuela

Before the 90s, sea cucumber fisheries in Venezuela were unknown, therefore no regulations existed. Biological and ecological studies on Venezuelan holothurids are very few; only some works on physiological aspects of two species, *Isostichopus badionotus* and *Holothuria mexicana* are available. Records of sea cucumber fisheries began in 1991–1992, when illegal catches were confiscated. These catches were made in the Mochima National Park area, northeastern Venezuela. No species, number of specimens or weight were reported. In 1993, despite the lack of knowledge in Venezuela, the Venezuelan Fisheries and Aquaculture Office Service of the Ministry of Agriculture issued the first commercial fisheries licence. One-year licences were issued to four boats to catch 200 kg/week, in the surrounding areas of Cubagua Island, northeastern Venezuela. These licences were suspended because no technical reports on the activity were submitted. In 1994, four new licences for commercial exploitation were authorised. This time two scientific institutions—Escuela de Ciencias Aplicadas del Mar, ECAM (Universidad de Oriente) and Estacion de Investigaciones Marinas (Fundacion La Salle)—agreed to submit technical reports on

captures, required for the development of management plans, regulations and authorising new licences. The fisheries area authorised were the neighbouring waters of Cubagua and Coche Islands, northeastern Venezuela.

Report from ECAM showed that fishing effort was concentrated on only two species: *I. badionotus* and *H. mexicana*. The average density (specimens per 1000 m²) was 93 and 69 for *I. badionotus*, and 14 and 17 for *H. mexicana*, in Coche and Cubagua islands, respectively. Both species were captured above a depth of 15 m. Total dry weight captures reported by two companies in approximately 5 months were 3.825 kg (with 8 boats) and 1.922 kg (with 4 boats).

In 1995, another illegal catch of 930 kg was confiscated in Los Roques National Park, northern Venezuela. In all these activities, legal or illegal, Asiatic entrepreneurs were involved. Studies and control policy on this resource are necessary to evaluate the possibility of its rational exploitation and to avoid natural populations' reduction or eradication.

2. Holothurian biology

Variation in alanine transport among sibling lecithotrophic larvae of holothuroid and asteroid echinoderms

by William Jaeckle

Friday Harbor Laboratories, Friday Harbor, WA 98250

Variation in development rate (e.g., time to metamorphic competence) among sibling larvae has been reported, but inter-individual differences in physiological processes has received comparatively little attention. All echinoderm larvae tested have a physiological capacity to assimilate dissolved organic materials (DOM) from seawater. Lecithotrophic larvae of holothuroid and asteroid echinoderms are sufficiently large to allow measurement of DOM transport in individuals and to determine variation among sibling larvae. Larvae of *Cucumaria miniata*, *Psolus chitonoides*, and *Solaster stimpsoni* (30–45 individuals) were added to 15 ml of seawater (9–9.5°C) and 14C-alanine was added to produce a concentration of 50–70 nM. At regular time intervals, 3–5 larvae were transferred to 200 ml of seawater, each was removed and placed in a separate tube, the residual seawater removed, and the radioactivity measured.

All larvae tested assimilated alanine from solution, but the worst rates varied among and within species. For *C. miniata* doliolaria and pentactula larvae, transport rates averaged 0.0195 ± 0.00129 pmol ala/larva-min (\pm standard deviation, n = 4 experiments). Transport rates of individual larvae varied and the r² of the regression line for each experiment was <0.70. When individual values were averaged per sampling time, the r² of the regression equations increased to >0.90. For both *Psolus* and *Solaster* there was less variation in transport rate among individuals. The transport rate of *Psolus* pentactulae was 0.021 pmol/ala larva-min (r² = 0.86) and rates of alanine transport by *Solaster* brachiolariae were 0.054 and 0.049 pmol ala/larva-min (r² of the regression lines were 0.82 and 0.92 respectively).

Observed differences among larvae are not a consequence of sample contamination or label absorption and represent true variation among individuals. The functional consequences of variation in the ability to remove DOM from seawater remain unknown, but these results indicate that there can be significant variation among individuals.

A taxonomic revision of some west coast cucumariid brooders

by P. Lambert

Royal British Columbia Museum, Victoria, Canada

Five nominal species of cucumariid sea cucumbers in the northeastern Pacific brood their young. In this paper the taxonomy of *Cucumaria lubrica* Clark, *Cucumaria curata* Cowles, *Pseudocnus astigmatus* (Wells), *Cucumaria pseudocurata* Deichmann, and *Cucumaria vegae* Théel, is revised, based on morphology and results from a study of mitochondrial DNA. The identity of *C. lubrica* is clarified and *P. astigmatus* is reduced to a junior synonym. The geographic range of *C. curata* is extended to British Columbia. *Cucumaria pseudocurata* and *C. vegae* are closely related and may be synonymous. DNA evidence suggests that brooding arose twice within this group of species.

The simulated deep-sea holothurian

By A. Smith¹, J. Matthiopoulos² & I.G. Priede¹

¹ Univ. of Aberdeen, Scotland, U.K.

² Univ. of Aberdeen/Macaulay Land Use Research Institute, Scotland, U.K.

The deposit feeding activities of many deep-sea holothurians make these animals important modifiers of the deep-sea sediment surface, either through mixing or repackaging and redistribution of material. The scale of the bioturbations will be greatly influenced by, among other factors, the population density, individuals' speed and search strategy of members of such fauna. We used computer simulations to investigate the range and sensitivity of areal coverage times to the ranging strategy assumed by a holothurian. Data for components of actual behaviour for the elaspod holothurian *Oneirophanta mutabilis* were drawn from time-lapse photography taken at a 4844 m sounding, (Porcupine Abyssal Plain, N.E. Atlantic). An individual *O. mutabilis* appeared in a sequence of 113 frames at one minute intervals, moving at an overall mean speed of 129 cm.hr⁻¹ (SD 68.3, range 18.9–333 cm.hr⁻¹) equivalent to 7.9 body lengths per hour. By assuming a systematic ranging strategy, a theoretical density of 15.63 indiv.10⁻³m⁻² would take a minimum of around 20.8 days to cover half the sediment area. At its most inefficient, employing a purely random ranging strategy simulation, the same density of *O. mutabilis* would take a maximum of around 32 y to cover the same half sediment area. An intermediate simulation incorporating observed distributions of speed and angles of turn, designed to emulate actual ranging behaviour, gave a half area coverage time of 16 y. These simulations reveal the sensitivity of areal coverage time estimates to the ranging strategy of the holothurian.

New records of the lagoon reef holothurians of Puerto Morelos, Quintana Roo, Mexico

by F.A. Solis-Marin, M.D. Herrero-Perezrul & A. Laguarda-Figueras

Lab. de Sistemática y Ecol. de Equinodermos, Inst. Ciencias del Mar y Limnol. Univ. Nacional Autónoma de México, Apdo. Postal 70-305, CP. 04510. México, D.F.

The holothurians of Puerto Morelos, Quintana Roo, Mexico, have never been made the object of investigation, although there are some reports for the general area of the Caribbean. Puerto Morelos is located at 21°00'N and 87°00'W. This area is influenced by the Yucatan Current. The specimens were collected on the lagoon reef, at 1–8 m depth, and obtained by SCUBA diving. The holothurians were found in different habitats. This contribution is based upon the collections made by the Instituto de Ciencias del Mar y Limnología, UNAM, and it is part of a more generalised project scheduled for 1995 to 1998. A total of 16 species were identified, of which 5 are recorded for the first time from Mexican waters (*Pseudothyone belli*, *Holothuria* [*Cystipus*] *pseudofossor*, *Synaptula hydriformis*, *Isostichopus macroparentheses* and *Epitomapta roseola*). The holothurians were classified as follows: 3 orders, 5 families and 9 genera. The family Holothuriidae was the most abundant. The nature of the holothurian fauna of Puerto Morelos was compared to other similar areas in the Atlantic Ocean.

Determining the nature of stiffness alteration in holothurian dermis using dynamic mechanical analysis

By G.K. Szulgit & R.E. Shadwick

Scripps Inst. of Oceanography, La Jolla, CA 92093-0204

Pieces of dermis from *Parastichopus parvimensis* were subjected to oscillatory shear strain. The dynamic storage and loss moduli were calculated and compared for tissues that were in stiff and compliant states. Tissues exhibited an increasing ratio of storage to loss modulus as they became more stiff, suggesting an increase in the prevalence of elastic linkages within the dermis. Extracts of the cellular contents within the dermis were obtained by subjecting the dermis to freezing followed by thawing. Outer and inner regions of the dermis were used to make two separate extractions. Tissues exposed to these solutions became compliant in the outer dermis extract, and stiff in the inner dermis extract. They did so in the absence of extracellular Ca²⁺. Based on the two parameters measured, these mechanical states were similar to those found in tissues that were taken directly from the animal and were exposed only to artificial seawater. This suggests that the stiffening and softening caused by the extracts is due to a physiologically relevant mechanism.

Microfibrils from sea cucumber dermis belong to the Fibrillin family, and their long-range elasticity is a crucial component of mutable collagenous tissues

by F.A. Thurmond¹, J.A. Trotter¹, T.J. Koob² & J.M. Bowness³

¹ Dept. of Anatomy, Univ. of New Mexico, Albuquerque NM, USA

² Skeletal Biology, Shriners Hospital, Tampa FL, USA

³ Dept. Biochem. Mol. Biol., Univ. of Manitoba, Winnipeg, Manitoba, Canada

Microfibrils (10–14 nm diameter) are abundant in the dermis of the sea cucumber *Cucumaria frondosa*, where they form an extensive network that surrounds and penetrates bundles of collagen fibrils. This network has been purified by extracting the tissue sequentially with 6M guanidine HCl and bacterial collagenase, which extracts everything except the microfibrils. Tensile testing of this network shows it to have a linear force-extension relationship up to almost 3 times its initial length, at which strain the network breaks. The network has an elastic modulus of about 2×10^5 N/m², which decreases markedly after reduction and alkylation. The breaking strength and strain however are unaffected by disulfide reduction. Rotary shadowed images of the microfibrils of this network reveal structures identical to fibrillin microfibrils from vertebrates.

The amino acid composition of the purified network gives it a high probability of being in the fibrillin family when compared with the SwissProt database. The network also strongly reacts with an antiserum to mammalian fibrillin microfibrils. The network was not found to possess any of the commonly found lysyl oxidase-mediated crosslinks such as hydroxyproline, pyridinoline, desmosine, or isodesmosine, nor did it contain dityrosine or trityrosine. It does possess large amounts of the transglutaminase-derived epsilon-(gamma-glutamyl) lysine crosslink, which has also been found in mammalian fibrillin microfibrils. This microfibrillar network with long-range linear elasticity is crucial to the function of mutable collagenous tissues because it surrounds and retains the dissociated collagen fibrils in organised proximity. It also is likely to contribute an elastic restoring force which helps tissues (which lack muscle) to recoil. The elastic microfibrils must be considered as a necessary mechanical contributor when models of mutable collagenous tissues are developed.

Non-collagenous proteins modulate the stiffness of sea cucumber dermis in vivo and interactions between isolated collagen fibrils *in vitro*

by J.A. Trotter¹, G. Lyons-Levy¹, D. Luna¹, Y. Chino¹, M.M. Koob-Emunds² & T.J. Koob²

¹ Univ. of New Mexico, Albuquerque, NM, USA

² Shriners Hospital, Tampa, FL, USA

Separate but intact native collagen fibrils, isolated from frozen and thawed inner dermis of *Cucumaria frondosa* by extensive washing in artificial sea water, aggregate in the presence of a purified fibril-binding glycoprotein also from the dermis. This novel glycoprotein, named 'stiparin', is a flexible molecule about 125 nm long with a monomer molecular weight of $\approx 375,000$ (Matrix Biology, in press). Stiparin is the most abundant soluble protein in the dermis. Previous work has shown that experimental plasticisation of inner dermis caused by calcium chelation is due to inhibition of Ca²⁺-dependent cellular processes; and that stiffening of the dermis caused by cell lysis in the presence of a calcium chelator is due to release of an organic stiffening factor (J. Exp. Biol. 198:1951 [1995]). This factor has now been purified from freeze-thaw extracts of inner dermis: it is a protein with a monomer molecular weight of $\approx 38,000$ (Bull. MDIBL, in press). In contrast to the inner dermis, outer dermis is plasticised by cell lysis. A protein has been purified from frozen and thawed outer dermis that, in the presence of either Ca²⁺ or a Ca²⁺-chelator, plasticises specimens of inner dermis.

This protein has a monomer molecular weight of $\approx 10,000$ (Bull. MDIBL, in press). Extracts containing the plasticising protein block the stiparin-dependent aggregation of collagen fibrils *in vitro*. Extracts containing stiffening protein inhibit this action of plasticizing protein. The following molecular model is suggested by these data: (1) collagen fibrils, which, in the absence of stiparin, are prevented from associating, perhaps by sulfate groups on surface glycosaminoglycans (Comp. Biochem. Physiol. 112A:463 [1995]); (2) stiparin, which binds to fibrils and causes them to associate; (3) plasticiser, which inhibits action of stiparin; and (4) stiffener, which blocks the action of plasticiser. Plasticiser and stiffener are postulated to be secretory products, since they are only obtained from dermis in which cells were lysed. The rate at which each is secreted would determine the plasticiser/stiffener molar ratio in the dermis. This, in turn, would determine dermis stiffness by regulating stiparin-mediated collagen fibril interactions.

Seasonality in asexual reproduction of three tropical aspidochirotid holothurians and the respiration of their fission products

by S. Uthicke

Inst. für Hydrobiologie und Fischereiwissenschaft, Hamburg, Germany & Australian Inst. of Mar. Sci., Townsville, Australia

Asexual reproduction by fission was monitored over a 16-month period in populations of *Holothuria* (*Halodeima*) *atra*, *H. (Halodeima) edulis* and *Stichopus chloronotus* on four reefs in the Great Barrier Reef, Australia. Fission by *S. Chloronotus* occurred exclusively between May and August with a peak of 21 per cent freshly divided animals in the population in June. *H. atra* showed a similar pattern also with a peak in June (26%). However, very few (<1%) individuals divided throughout the year. In *H. edulis*, asexual reproduction only occurred between February and May with a maximum proportion of 17 per cent divided individuals in March.

Respiration rates of intact individuals and recently (<2 weeks) divided individuals were measured for all three species in data-logging respirometers. For all species, power functions were fitted to describe biomass-specific oxygen consumption rates for intact individuals, and for anterior and posterior sections. There were no differences in biomass-specific respiration rates between the two fission products of all species. In *H. atra*, the respiration rate of fission products was on the same level as that of intact individuals. Compared to intact individuals, fission products of *H. edulis* and *S. chloronotus* showed a 32–47 per cent and 50 per cent decrease in respiration rate, respectively. Dissections of the two *Holothuria* species revealed that most of the intestines, including the respiration organs (water lungs) were retained in the posterior sections after fissions. In contrast, *S. chloronotus* lost the complete gut, including its respiration organs, during the fission process. Hence, both sections of *S. chloronotus* and the anterior sections of *H. atra* and *H. edulis* are able to sustain a considerable proportion of the respiration rate of complete individuals without their water lungs, presumably by respiration via the body wall and uptake of water into the body cavity.

Phagocytosis of sea cucumber amoebocytes: a flow cytometric study

by Jun Xing & Fu-Shiang Chia

Dep. of Biol., Hong-Kong Univ. of Science & Technology, Clear Water Bay, Kowloon, Hong Kong

The present study was designed to document the quantitative aspects of phagocytosis by amoebocytes in the black sea cucumber, *Holothuria leucospilota*, using the flow cytometric method. The percentage of phagocytic cells, the number of ingested fluorescence latex beads per cell and the total number of beads ingested were quantified simultaneously at different bead/cell ratios (5, 10, 25, 50, 100 and 200). It was found that 96 per cent of amoebocytes were functionally phagocytic and the percentage of phagocytic cells as well as total number of ingested beads were positively correlated with bead/cell ratio. Within 2 hours, 3 million beads were ingested by 0.5 million amoebocytes, indicating the high efficiency of the amoebocytes to cleanse foreign particles. This study, the first quantitative analysis of phagocytosis in echinoderms by a flow cytometric method, provides new insight into the defence mechanism of sea cucumbers. Of the 50 million coelomocytes in an adult animal, about half of them are amoebocytes.

Reproduction and development of the apodous holothurian *Chiridota rotifera* (Pourtales, 1851), in the laboratory

by V.F. Hadel, C.G. Tiago, A.S.F. Ditadi & G.Y. Kawauchi

Centro de Biologia Marinha / Instituto de Biociencias – Universidade de Sao Paulo

Chiridota rotifera is a small apodous holothurian occurring in coarse sand, at the intertidal zone in Sao Sebastiao, Sao Paulo State, Brazil (23°49'S and 45°25'W). An attempt to rear these animals in the laboratory has been conducted since 1993. Individuals of *C. rotifera* were kept in 350 ml plastic cups containing a layer of 150 ml of sand from the same place where the first specimens were collected and 140 ml of sea water. Some cups contained only one individual, whereas others contained a pair, or up to ten animals. They were kept in constant temperature chambers at 22°C in the dark. *C. rotifera* are viviparous, brooding their young in the coelom. Until April 1996, 2231 individuals were born in cups containing between two and four animals, but none of the isolated individuals

reproduced. The first generation raised in the laboratory produced 1631 new holothurians, which later on produced 528 newborn, which constituted the second generation produced under laboratory conditions. A third generation began to be born in March 1996, amounting to 72 specimens up to date. The initial 304 young born in the laboratory died, but since November 1994 only 43 of 1927 born individuals were lost. Of the remaining animals, 1691 were released in their natural environment, and 193 were kept for studies. The average length of the newborn animals was 5.9 mm (SD = 1.6; n = 500), ranging from 1.2 to 12.5 mm. Some of the animals born and kept in the laboratory reproduced when they were almost 6 months old. The number of newborn per brood varied from only one up to 84 animals. Although the ambient temperature was held constant, most of the animals were born from October to February, the warmest months in the Southern Hemisphere. This may show a tendency for these animals to reproduce in the summer.

Spatial and temporal distribution of feeding of Aspirochirotida (Holothuroidea) on Heron Island, Great Barrier Reef

by T.S. Klinger¹ & C.R. Johnson²

¹ Bloomsburg University, Bloomsburg, USA

² University of Queensland, Brisbane, Australia

Aspidochirotida are distributed throughout the reef flat of Heron Island, contributing 34–44 g wet weight of biomass per square metre. On the reef flat, feeding by *Holothuria edulis* and *Stichopus chloronotus* is concentrated on sediments 0–5 cm from coral outcroppings, while *H. atra* and *H. leucospilota* feed at 9–15 cm from coral outcroppings. Reef flat sediments actively fed upon by Aspidochirotida do not differ significantly ($p > 0.05$) in total organics, chlorophyll a, or phaeophytin from sediments not being fed upon. Spatial variation in the apparent food quality of sediment is low and probably does not contribute to the distribution of Aspidochirotida on the reef flat. In the lagoon, Aspidochirotida are highly aggregated around the bases of coral patch reefs, where their biomass can reach 210–220 g wet weight per square metre. Biomass of Aspidochirotida approaches 0 beyond 15 m from coral patch reefs. Sediments at the bases of coral patch reefs in the lagoon do not differ in total organics, chlorophyll a, or phaeophytin from sediments at 20 m distance. However, sediments at the bases of coral patch reefs contain significantly more protein and are significantly skewed toward the coarser grain sizes (ϕ -1.5 to 1.5). This suggests either that Aspidochirotida in the lagoon aggregate in areas of higher quality sediment, or that intense feeding by Aspidochirotida alters the composition of sediment near coral patch reefs. Most Aspidochirotida feed continuously. *H. atra*, *H. edulis*, *H. leucospilota* and *Stichopus variegatus* do not exhibit any circadian rhythm in feeding or the passage of sediment through the gut, whereas *S. chloronotus* demonstrates a clear circadian rhythm, extending oral tentacles more frequently and passing more sediment in the afternoon and evening than in the morning. The aggregated spatial distribution of Aspidochirotida, and the spatial separation of some species, is not driven by resource availability and niche partitioning, but rather by some other factor, such as the availability of shelter.

Effect of diet on growth and larval development of the sea cucumber *Holothuria nobilis* in Guam (poster)

By P.C. Martinez¹ & R. H. Richmond²

¹ Charles Darwin Research Station, Santa Cruz, Galapagos, Ecuador.

² University of Guam, Marine Laboratory, Mangilao Guam 96923.

The effects of diet on larval growth, development, and survival of the economically valuable sea cucumber *Holothuria nobilis* (Selenka) was studied under laboratory conditions. Adult sea cucumbers were collected from the reefs of Guam and induced to spawn in the laboratory. Two sets of experiments were conducted at different times, each with a duration of 30 days. Larvae were raised on the following diets: 0.45 mm filtered seawater (unfed), natural seawater, and cultured algae including Tahitian (T-) *Isochrysis*, *Pavlova salina*, and a mixed culture of T-*Isochrysis* and *P. salina*. Five 1-litre replicate glass bottles were used for each diet, and larvae were raised at a larval density of 1000/bottle. Larval length at the secondary auricularia stage was largest for larvae that were raised on the T-*Isochrysis* and natural seawater diets, and significantly smaller for the unfed larvae.

Larval development was initially fastest for larvae raised on natural seawater, with 78 per cent of the individuals reaching the secondary auricularia stage within one week. However, from week two until the end of week four, development was slower for larvae raised on the natural seawater and T-*Isochrysis* diets compared to those on the

unfed treatment. Unfed larvae had faster development than the larvae of any of the other treatments; with 37 per cent larvae reaching the doliolaria stage by week four.

Larval survival was very low on the mixed diet treatment with a mean survival of 1.4% compared to 52% and 26% for T- *Isochrysis* fed and unfed larvae. Results indicate that diet has a major influence on growth, development, and survival of *H. nobilis* larvae, but other factors may also affect the ability of larvae to complete metamorphosis.

Characteristics of a population of *Holothuria floridana* (Echinodermata: Holothuroidea) in the Florida keys (poster)

by C.M. Pomory, T.W. Foret, S. Hill & J.M. Lawrence

University of South Florida, Tampa, Florida 33620

In March 1996, a survey of the population from seagrass beds in a small channel between the west Content Keys was done along two 170 m transects, 9 m and 25 m from shore. The habitat in each square metre was classified as algal/sand (mainly *Halimaeda incrassata*), sparse grass or thick grass (mainly *Thalassia testudinum*), and the number of *H. floridana* counted. Nineteen sediment samples were collected from the combined transects for grain size analysis. Fifteen individuals were haphazardly selected for analysis of gut sediment grain size and proximate analysis of the body wall. The 9 m transect contained 27 individuals, and the 25 m transect contained 93 individuals. Of the total population (173 mm mean length) 13 per cent was found in algal/sand, 28 per cent in sparse grass and 59 per cent in thick grass. None of the individuals were regenerating. The frequency distributions between transects and between habitats were significantly different from an equal probability distribution (G-test, $p < 0.05$). Sediment grain size distribution from the transects was 10.3% $<149 \mu\text{m}$, 28.5% $149-297 \mu\text{m}$, 30% $297-595 \mu\text{m}$, 5.6% $595-841 \mu\text{m}$ and 25.6% $>841 \mu\text{m}$, not significantly different from the gut contents except for the smallest size fraction of 18% (ANOVA, $p < 0.01$). The body wall (78 g mean wet weight) contained 86% water. On a dry weight (11 g mean) basis, it was 21% ash, 46% NaOH-soluble protein, 3% lipid, 3% carbohydrate and 27% insoluble material, probably structural proteins; equivalent to 15.6 kJ/g dry weight, 19.7 kJ/g ash-free dry weight and 60 kJ/m². The occurrence of large individuals primarily in dense seagrass beds may be related to the baffling effect of the grass blades that would cause the accumulation of fine particles, or to the provision of cover.

A review of the holothurian family Gephyrothuriidae

by P. Mark O'Loughlin

Museum of Victoria, Melbourne, Australia

The family Gephyrothuriidae Koehler & Vaney, 1905 was erected for the monotypic genus *Gephyrothuria* Koehler & Vaney. H.L. Clark (1907) added a second monotypic genus *Himasthlephora*, which Hérouard (1923) synonymised with *Gephyrothuria*. Heding (1935, 1940) added an initially monotypic genus *Molpadiodemas*, subsequently referred three synallactid species to *Molpadiodemas*, and included in the Gephyrothuriidae the genera *Pseudostichopus* Théel, *Trachostichopus* Heding, *Filithuria* Koehler & Vaney, *Plicastichopus* Heding, *Paroriza* Hérouard, *Platystichopus* Heding and *Benthothuria* Perrier. Djakonov (1952) added a monotypic genus *Peristichopus*, and Hansen (1956) referred a monotypic genus *Hadalothuria* to the Gephyrothuriidae. F.W.E. Rowe (in Rowe & Gates, 1995) followed Heding (1940), but synonymised *Trachostichopus* Heding and *Plicastichopus* Heding with *Meseres* Ludwig, including *Meseres* in the Gephyrothuriidae. Hansen (1956), Pawson (1982), Thandar (1992) and Gilliland (1993) did not follow Heding (1940), and by inference restricted the family to the genera *Gephyrothuria* Koehler & Vaney and *Hadalothuria* Hansen. Based principally on the systematic significance of tentacle form at order and family level, the family is restricted herein to *Gephyrothuria* Koehler & Vaney, *Molpadiodemas* Heding and *Hadalothuria* Hansen, genera which have digitate tentacles. *Molpadiodemas* is restricted to the species *M. acaudum* Heding, which has digitate tentacles. In the current absence of adequate morphological and molecular evidence on which to base further higher taxa, the excluded genera with predominantly peltate tentacles are at this stage referred to the family Synallactidae from which many of them were transferred by Heding (1940) without reference to tentacle form. Based on an examination of material in good condition taken off eastern Australia and held in the Australian Museum and Museum of Victoria, and on direct comparison with syntypes of *Gephyrothuria glauca* (H.L. Clark) held in the Museum of Comparative Zoology at Harvard, *Gephyrothuria glauca* (H.J. Clark, 1907) and *G. europeensis* Hérouard, 1923 are synonymised with *Gephyrothuria alcocki* Koehler & Vaney, 1905.

Elasipod holothurians from the continental slope of Australia

by P. Mark O'Loughlin

Museum of Victoria, Melbourne, Australia

Based on Australian Museum material, Rowe and Gates (1995) recorded six bathyal elasipod holothurian species for the continental slope off eastern Australia—*Oneirophanta mutabilis* Théel, *Laetmogone violacea* Théel, *L. maculata* (Théel), *L. fimbriata* (Sluiter), *Pannychia moseleyi* Théel and *Benthodytes lingua* Perrier. Six additional elasipod species are reported herein for further material collected from the slope off southeastern Australia and held in the Museum of Victoria—*Deima validum validum* Théel, *Benthogone rosea* Koehler, *Peniagone vitrea* Théel, *Amperima furcata* (Hérouard), *Elpidia theeli* Hansen and a *Peniagone* Théel species. The Museum of Victoria material also includes numerous specimens of *Laetmogone violacea* Théel, *L. maculata* Théel and *Pannychia moseleyi* Théel. The *Peniagone* species is characterised by having typically seven pairs of pedicels on the posterior half of the body; two pairs of anterior dorsal radial papillae posterior to the velum; a body four times as long as broad; and very spinous ossicles with distinct stem, four arms and four apophyses, dorsal ossicles with arms strongly downturned and ventral ones with arms slightly downturned.

These features are shared most closely with *P. challengeri* Théel from south of Australia, and *P. papillata* Hansen from the eastern Pacific. Of the six species reported by Rowe & Gates (1995), *Benthodytes lingua* Perrier was previously known only from the north and south Atlantic and *Oneirophanta mutabilis* Théel was known from the deep-abyssal zone. Of the six species reported herein *Amperinma furcata* (Hérouard) was previously known only from the northeastern Atlantic, *Peniagone vitrea* Théel is reported for the first time from the western Pacific, and both *Deima validum validum* Théel and *Elpidia theeli* Hansen were previously known in this region from the abyssal depths of the Tasman Sea. The remaining five species were known from bathyal depths in this region of eastern Australia, the Tasman Sea and New Zealand. In addition to these eastern Australian records, *Benthodytes sanguinolenta* Théel is represented in the Museum of Victoria collections by two specimens from the continental slope off central Western Australia. Thirteen elasipod species are recorded for the continental slope of Australia.

A new dendrochirote holothuroid from deep waters of the west coast of South Africa

by A.S. Thandar

University of Durban-Westville, Durban, South Africa

The order Dendrochirotida of the class Holothuroidea is well represented in southern Africa where approximately 50 species have so far been recorded. Deep-water dredgings undertaken by the South African Museum have brought to light several specimens of a new species, referable to the cucumariid genus *Paracucumaria*. This genus was erected by Panning (1949) to accommodate the type species, *Cucumaria mauritanica* Hérouard, *C. hyndmani* Thompson, *C. tricolor* Sluiter, *C. glaberrima* Semper and *C. parva* Ohshima. The latter three species have long been transferred to other genera. However, in 1971, in his re-assessment of certain cucumariid genera, Panning concluded that *P. hyndmani* should be referred to *Panningia*, a genus erected by Cherbonnier (1957) for some east Atlantic forms.

However, unaware of *P. thallasae*, described by Cherbonnier in 1969, Panning concluded that the genus *Paracucumaria* had become monotypic, represented by the type of species which possesses, in addition to the smooth plates of the body wall, baskets in the anal region. Since then, one other species, namely *P. deridderae* Massin, 1993, has been described. To the three species is now added a fourth species taken from deep waters off the west coast of South Africa. This species was originally suspected to be a *Trachythyone* and described as *T. parva* by Thandar (1991). The new species differs from others in the genus *Paracucumaria* by the equal size of the tentacles, the distribution of the pedicels, the form of the radial plates and the presence of large, multi-ocular, smooth plates in the general body wall and cup-like baskets, usually in the anal region. It is noteworthy that, like the Rhopalodinidae, the genus *Paracucumaria* is limited in its distribution to the west coast of Africa and appears to be allied to *Trachythyone* and *Leptopentacta*. However, it is doubtful whether *P. deridderae* really belongs to this genus as Massin illustrates mostly knobbed spinous plates from the body wall of his species and makes no mention of anal spicules.

Other abstracts and publications

compiled by C. Conand

Commercial fishing and organic composition of *Isostichopus fuscus* Ludwig, 1875 from the Galapagos Islands

by J. Sonnenholzner¹, N. Camba¹ and J. M. Lawrence²

¹ Instituto Nacional de Pesca del Ecuador, Guayaquil, Ecuador. E-mail: inp@inp.gov.ec

² University of South Florida, Tampa, Florida.

The sea cucumbers from the continental coasts of Ecuador and the Galapagos Islands have been fished without any control for approximately eight years. This commercial species, *Isostichopus fuscus*, is distributed in the western zone of the Galapagos Islands and the central Ecuadorian coast, particularly between La Plata Island, 9 miles from the coast of Manabi coast, and Ayangue Beach on the Guayas coast. It is the sea cucumber most commonly found in shallow waters. The proximate composition of the body wall was measured for specimens collected on April 1993 at the eastern coast of the Fernandina Island along the Bolivar Channel from Punta Mangle (0°25'S, 91°23'W) to Punta Espinoza (0°15'S, 91°26'W). The concentrations of ash (1.0–1.5%), protein (2–4%), fat (3.1–3.6%) and carbohydrates (<1%) were all low as the water content was high (93.5%). Carbonate and chloride concentrations were very low (<1%). The body wall of *I. fuscus* is not a high-quantity protein food source.

Species and size related trends in asexual propagation of commercially important species of tropical sea cucumbers (Holothuroidea)

by Norman Reichenbach, Yoosuf Nishar and Ahamed Saeed

Oceanographic Society of Maldives, P.O. Box 2075, Malé, Republic of Maldives

(E-mail: Norm.Reichenbach@lfa.com)

In: Journal of the World Aquaculture Society. December 1996. 27 (4).

Juveniles of four species of tropical sea cucumbers of moderate to high commercial value were studied to determine their potential for being propagated asexually by evaluating their survival and regeneration times after being forced to undergo transverse fission. The species were *Holothuria fuscogilva*, *H. nobilis*, *Actinopyga mauritiana*, and *Stichopus variegatus*. Rubber bands placed midbody on the sea cucumbers provided an effective yet simple technique to induce fission. Posterior parts of animals had similar or higher survivorship and shorter regeneration times relative to the anterior parts. Combining this information with that collected earlier on adults indicated that smaller animals (both anterior and posterior parts) had higher survivorship (up to 100%) and shorter regeneration times (as fast as 41 days) relative to adult animals of the same species. Using per cent weight retained after processing into beche-de-mer a rough measure of body wall thickness, and size of the animal relative to the adult weight, a multiple regression equation was calculated to predict per cent survival and regeneration times for both anterior and posterior parts. The equation illustrated that small, thin-walled species would have the highest survivorship and shortest regeneration times. As the per cent weight retained increased, as would be the case with more thick-walled species, and as the animal approached the adult weight, survivorship declined and the regeneration time increased.

Conservation of sea cucumbers

by D.B. James

Central Marine Fisheries Research Institute, Cochin – 682 014

In: N.G. Menon and C.S.G. Pillai (eds.) Marine bio-diversity, conservation and management, Central Marine Fisheries Research Institute, Cochin. 80–88.

Over the years there has been a decrease in the landings of sea cucumbers all over the Gulf of Mannar and Palk Bay along with a drop in the size of the specimens collected. The catch per unit of effort has also significantly fallen in the recent years. All these factors point to over-exploitation of the sea cucumbers and need for their conservation.

Culture of sea cucumber

by D.B. James
Central Marine Fisheries Research Institute, Cochin – 682 014

In: Bull. Cent. Mar. Fish. Res. Inst. 48: 120–126. 1996.

'Deep-water redfish', a new resource for the Indian beche-de-mer industry

by D.B. James & M. Badrudeen
Central Marine Fisheries Research Institute, Cochin – 682 014

In: Mar. Fish Inform Service. 137: 6–8. 1995.

Taxonomic studies of the species of *Holothuria* (Linnaeus, 1767) from the seas around India

In: Journal, Bombay Nat. Hist. Society. 92(1): 43–62. 1995.

Part 1, by D.B. James

In this paper earlier attempts made to revise the genus *Holothuria* Linnaeus, 1767 are given in detail. Of the 26 species known under the genus *Holothuria* from Indian seas, 18 species have been collected by me. These have been described in detail with full synonymy, notes on habits and remarks with figures and photographs. Keys have been provided for all the species known from the Indian seas.

Part 2, by D.B. James

Holothuria (*Mertensiothuria*) *leucospilota* (Brandt) (Pl. 2, A; 3, A–C).

Stichopus (*Gymnochirota*) *leucospilota* Brandt, 1835, p. 51.

Holothuria vagabunda Bell, 1886, p. 28: Mergui Archipelago; Bell, 1887a, p.140: Andaman Island; Bell, 1888, p. 389: Tuticorin (Gulf of Mannar); Thurston, 1894, p. 11.5: Tuticorin (Gulf of Mannar); Pearson, 1903, p.201: Ceylon (Sri Lanka); Koehler & Vaney, 1908, p. 17: Andaman Island; Laccadives (Lakshadweep).

Holothuria leucospilota A.M. Clark & Davies, 1966, p. 603: Maldives; James, 1969, p. 62; Gulf of Mannar, Arabian Sea, Andamans, Laccadives (Lakshadweep); James, 1982, p. 5; Tikader & Das, p. 99: Andaman & Nicobar Islands; James, 1987, p. 110: Hut Bay (Little Andamans).

Holothuria (*Mertensiothuria*) *leucospilota* James, 1982, p. 92: Goa (West coast of India); Soota, Mukhopadhyay & Samanta, 1983, p. 511: Trinket, Nancowry Harbour, Sound Island (Andaman & Nicobar Islands); Mukhopadhyay & Samanta, 1983, p. 305: Lakshadweep; Price & Reid, 1985, p. 4: Galle (Sri Lanka); James, 1986a, p. 585: Lakshadweep-Maldives, Sri Lanka, Gulf of Mannar, Palk Bay, Andaman-Nicobar Islands; James, 1989, p. 127: Chetlat, Kiltan, Kadmat, Amini, Androth, Kavaratti, Minicoy (Lakshadweep).

Morphology of the Pentactulae of holothurian *Cucumaria japonica* (*Dendrochirota*, *Holothuroidea*) at different developmental stages

by I. Yu. Dolmatov, N.D. Mokretsova
Institute of Marine Biology, Russian Academy of Sciences, Far-Eastern Branch, Vladivostok, Russia, and Pacific Institute of Fishery and Oceanology, Valdivostok, Russia

The morphology of the pentactulae of holothurian *Cucumaria japonica* at different stages was studied. One and a half months after fertilisation, the architectonics of pentactulae is similar to that of adult holothurians. Five tentacles, 5 radial ambulacral canals, the Polian vesicle and the stone canal are present. The nervous system consists of a nerve ring, tentacular nerves and radial nerve cords. The longitudinal muscles are developed at the ventral radius.

The gut consists of several parts. Gonads and respiratory trees are absent in pentactulae of all the studied ages. In the process of metamorphosis, the most important changes take place in the digestive tract and in the stone canal. In 4-month old pentactulae, the stone canal loses its connection with external environment and the dydropore is shut. The madreporite arises as an outgrowth of the wall of stone canal just above the coelomic epithelium. At this period (1.5 to 4 months), the gut passes through three phases of development. These phases are correlated with functional changes in the digestive system and the changes of feeding mode of pentactulae.

Screening for antibacterial agents in three species of sea cucumbers from coastal areas of Sabah

by B.H. Ridzwan, M. A. Kaswandi, Y. Azman and M. Fuad.

Department of Biomedical Sciences, Faculty of Allied Health Science, Universiti Kebangsaan Malaysia, 50300 Jalan Raja Muda Abdul Aziz, Kuala Lumpur, Malaysia.

In: Gen. Pharmac. vol. 26, no. 7, 1539–1543. 1995.

Asexual reproduction by fission in *Holothuria atra*: variability of some parameters in populations from the tropical Indo-Pacific

by Chantal Conand.

Laboratoire d'Écologie Marine, La Réunion

In: Oceanologica Acta, vol. 19, no. 3–4. 1996.

Holothuria atra is the most common aspidochirotid holothurian on tropical Indo-Pacific reefs. Asexual reproduction by transverse fission, followed by regeneration, has been studied at Reunion Island (Indian Ocean) and compared with different populations of the Indo-Pacific zone, thus permitting a better identification of the most significant parameters and a better understanding of this reproductive strategy.

At Reunion Island, the species is studied at two stations on the same fringing reef: 1) on the back-reef where the fission rate is high (20% of the population), the individuals small (generally weighing less than 150 g) and the population density high (4/m²); and 2) on the reef front, where fission is extremely rare, the mean size of the individuals larger (up to 300 g) and the density low (0.01/m²). Different categories of individuals, fissioning (F), after fission, anterior and posterior parts (A and P), and regenerating (Ap and Pa) have been identified from external observations.

Dissection has demonstrated the unequal allocation of organs during fission and the variability of the regenerative states, mostly in the anterior part. Concerning fission, the position of the split in an individual is in the anterior half (at 44% of the total length). The monthly incidence of fission is higher from October to January and in June-July. Fission does not result in an increase in the density of the population.

The monthly rates of regenerating individuals originating from anterior (3.7%) and posterior (6.1%) parts suggest that survival is higher in the latter instance. The occurrence of asexual reproduction in various populations of this species is discussed in relation to the ecology and the parameters of the populations considered. On the back-reef studied at Reunion Island, the population is subtidal and emersion cannot explain fission. Anthropogenic disturbances are possible triggers of this phenomenon.

Ultrastructural organisation of contractile systems in the Holothurian *Eupentacta fraudatrix*

by I. Yu. Dolmatov.

Institute of Marine Biology, Far East Division, Russian Academy of Sciences, Valdivostok, 690041.

In: Russian Journal of Marine Biology, Vol. 21, No. 2. 1995. 119–123. Original Russian text copyright (1995) by Biologiya Morya, Dolmatov.

Morphology of the contractile systems of the holothurian *Eupentacta fraudatrix* are examined using transmission electron microscopy techniques. The largest muscles are the longitudinal muscle bands and the retractor. They

have a similar structure and consist of separate muscle bundles surrounded by connective tissue. Each bundle is composed of 8 to 20 cells and is surrounded by a basal lamina; myocytes anchor the latter by means of hemidesmosomes. The muscle cells are polarised; myofibrils are located in the peripheral basal part of a cell, and the nucleus and cytoplasm with organoids are located in the apical part in the center of a bundle. The muscles of the body wall, gut, and respiratory trees are represented by folded coelomic epithelium composed of epithelio-muscle cells. It is concluded that the formation of myoepithelial folds represents an intermediate stage in the evolution of muscles as three-dimensional systems.

Muscle ultrastructure and growth of the pentactula of the holothurian *Eupentacta fraudatrix*

by I. Yu. Dolmatov.

Laboratory of Comparative Cytology, Institute of Marine Biology, Far East Branch, Russian Academy of Sciences, Vladivostok, 690041 Russia.

In: Russian Journal of Marine Biology, Vol. 21, No. 1. 1995. 64–68.

The Morphology and growth of longitudinal muscle bands (LMB) in one-year old holothurians *Eupentacta fraudatrix* was examined by transmission electron microscopy. The LMBs are covered by a flattened ciliated coelomic epithelium and consist of muscle bundles encircled by connective tissue. A basal lamina separates each bundle from the extracellular matrix. New muscle bundles arise from a coelomic epithelium. Myofibrils begin to form in the processes of some coelomic epithelium cells (myoblasts). The amount of myofibrils gradually increased and the cell groups deepen into the connective tissue of muscle. At the same time, young myocytes form their own basal lamina. This results in a formation of a new line of muscle bundles just under the epithelium. A conclusion is made that the histogenesis processes in both development and growth of holothurian muscles are identical, at least during the first years of life.

Muscle regeneration in the holothurian *Stichopus japonicus*

by Igor Yu Dolmatov, Marina G. Eliseikina, Alexander A. Bulgakov, Talia T. Ginanova, Nina E. Lamash & Valadimir Korchagin.

In: Roux's Arch. Dev. Biol. 1996.

The regeneration of longitudinal muscle bands (LMBs) in the sea cucumber *Stichopus japonicus* was studied using light and electron microscopic and immunocytochemical methods. Previous investigations of holothurian organs showed the presence of some cytoskeletal proteins which were specific for LMBs only. One of them, the 98 kDa protein, was isolated by means of SDS electrophoresis and used as an antigen to obtain polyclonal antibodies. When tested on paraffin sections of sea cucumber organs, the antibodies were shown to interact only with coelomic epithelial cells covering the LMBs. The antibodies were used to study LMB regeneration after transverse cutting. During regeneration no signs of myocyte dedifferentiation or mitotic division were observed. In the wound region, damaged myocytes degenerated and muscle bundles desintegrated. However, the coelomic epithelial cells dedifferentiated and began to invade the LMB. Just beneath the surface these cells formed clusters (muscle bundle rudiments). The number and size of clusters gradually increased, the cells lengthened and developed contractile filaments. These observations suggest that new muscles arise from coelomic epithelial cells covering LMBs. The migration of coelomic epithelial cells into the damaged LMBs and their myogenic transformation are the basic mechanism of holothurian muscle regeneration.

On a *Psolus* species encountered in Kraternaya Bight (Ushishir Island, the Kurile Islands)

by A.V. Smirnov

Zool. Inst., Russ. Acad. Sci., St. Petersburg 199034, Russia.

In: Biologiya Morya (Vladivostok), 21 (1). 1995. 83–84.

The paper deals with species identification and distribution of a holothurian, *Psolus* sp., from Kraternaya Bight of Yankicha Island (the Kuriles).

Two new holothurians (Echinodermata: Holothuroidea) from an anchialine lagoon of an uplifted atoll, Kakaban Island, East Kalimantan, Indonesia

by C. Massin & T. Tomascik.

Dep. Invertebrates, Royal Belgian Inst. Nat. Sc., 29 rue Vautier, 1000 Brussels, Belgium.

In: Raffles Bulletin of Zoology 44(1). 1996. 157–172.

Two new species of holothurians, *Holothuria (Lessonothuria) cavans* (Holothuriidae) and *Synaptula spinifera* (Synaptidae) are described from an anchialine lagoon on the raised atoll island of Kakaban, East Kalimantan, Indonesia.

Morphology of the pentactulae of holothurian *Cucumaria japonica* (Dendrochirota, Holothurioidea) at different developmental stages

by I. Yu Dolmatov & M.D. Mokretspva.

Inst. Mar. Biol., Far East Div., Russ. Acad. Sci., Vladivostok 690041, Russia.

In: Zoologicheskii Zhurnal, 71(1). 1995. 83–91.

Ultrastructural characteristics of the digestive epithelium in *Cucumaria japonica*

by M.G. Eliseikina & N.L. Leibson.

Inst. Mar. Biol., Far East Div., Russ. Acad. Sci., Vladivostok 690041, Russia.

In: Biologiya Morya (Vladivostok), 22(2). 1996. 102–109.

Effect of compounds elevating cyclic nucleotide levels on dithiothreitol-induced oocyte maturation in the holothurian *Stichopus japonicus*

by E.M. Karaseva & Yu S. Khotimchenko.

Lab. Cellular Physiol. Pharmacol., Inst. Marine Biol., Far East Branch, Russian Acad. Sci., Vladivostok 690041, Russia.

In: Comparative biochemistry and physiology C pharmacology toxicology and endocrinology, 111(3). 1995. 441–444.

Muscle repair in the holothurian *Eupentacta fraudatrix* is realised through transdifferentiation of the coelomic epithelium cells

by I. Yu. Dolmatov, M.G. Eliseikina & T.T. Ginanova.

Institute of Marine Biology, Far-Eastern Branch of the Russian Academy of Sciences, Vladivostok, 6990041 Russia. Received 17 September 1994.

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Regeneration of longitudinal muscle bands in the holothurian *Eupentacta fraudatrix* was studied using light and electron microscopy. It has been shown that new muscle bundles are formed from the coelomic epithelium cells. Migration and submergence of the coelomic epithelium cells in the connective tissue and their myogenic differentiation are the main mechanisms underlying muscle repair in these animals.

No mitotic activity was observed in the regenerate tissues. A conclusion was drawn that multipotency and liability of differentiation of the coelomic epithelium is its primary property, which was preserved, which was preserved during evolution in the Celomata with respect to asexual reproduction and regeneration.

Growth estimates by the size distribution of sea cucumber, *Stichopus japonicus* Selenka, in the artificial pools in Toyosaki, Minamikayabe-chou, southern Hokkaido

by Hiroshi Hoschikawa, Kazuhiro Takahashi, Yukihiro Konno & Tooru Miyagawa.

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The size distribution of a sea cucumber, *Stichopus japonicus* Selenka, was investigated in the artificial intertidal pools and rocky subtidal area in Toyosaki, Minamikayabe-chou, southern Hokkaido. The density of juveniles was higher in the intertidal pools (6.67/0.25 m²) than the rocky subtidal (0.33/0.25 m²). The body weights of 1⁺ and 2⁺ in October were estimated as ca. 10g, and ca. 40g, respectively.

Marine species collected by women in Palau, Micronesia

by Elizabeth Matthews¹ & Evelyn Oiterong²

¹ University of Oregon, Micronesia Programme

² Division of Marine Resources Koror, Palau

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Women in Palau, Micronesia regularly collect sea cucumbers, molluscs, urchins, crabs, and reef fish from shallow nearshore areas according to a survey of 54 Palauan women. This article describes the most common methods Palauan women utilise to collect marine species for subsistence and local commercial purposes. Of the women interviewed, most collect invertebrates by reef gleaning. Some women collect mangrove clams, commercially their most important species. Some women catch land crabs, coconut crabs or mangrove crabs. Many women use handlines to catch reef fish. Few women use spearguns or nets to catch fish. There is some concern among the women that several of the invertebrates they collect are harder to find now than they were in the recent past. In particular, the women are concerned about the status of stocks of giant clams, short-spined urchins, mangrove clams, and a species of swimming crab that is collected for subsistence use.

Fishery dynamics, ecology and management of beche-de-mer at the Warrior Reef, Torres Strait protected zone, Papua New Guinea

by Paul Lokani.

Master of Science thesis, December 1995. Dipl. Fish. Tech., BSc (PNGUT). James Cook University

An artisanal fishery for sea cucumbers at the Warrior Reef commenced in 1990 but was closed in 1993 as a result of over-exploitation of the target species *Holothuria scabra*. To assist in the appropriate management of the fishery when re-opened, a study was conducted to (i) document and analyse existing fisheries data, (ii) describe patterns of distribution and abundance of common sea cucumber species found on the reef flat, (iii) determine the reproductive biology of *H. scabra* and (iv) describe patterns of movement for *H. scabra*.

Analysis of fisheries records over four years (1990–1993) indicates peak catches of *H. scabra* in 1991–1992, which subsequently declined, with the fishery shifting to several less valuable species. Fishing did not appear to be size selective. As sites were fished out, exploitation moved further afield until the fishery was closed. The rapid depletion of populations during intensive fishing and a depletion experiment provided estimates of the total exploitable stock using the Leslie model. Application of Gulland's surplus production model resulted in extremely low estimates of maximum sustainable yield (2.96 kg per hectare per year) of 49 t for the whole reef.

The distribution and abundance of sea cucumbers that occupy the reef flat at the Warrior Reef are unknown. Using visual census techniques, patterns of distribution and abundance were tested at two reefs, three zones and thirty sites. The mean density was not different among reefs and zones but was significantly different among sites for *H. scabra* which was found to comprise from 10 to 30 per cent of the individuals found at each zone. Two other dominant species were *Holothuria atra* and *Bohaschia similis* which, together with *H. scabra*, comprised from 50 to 90 per cent of the individuals in each zone. Species richness ranged from 12 to 14 per zone and remained about the same in the two reefs. Sizes encountered on the reef flat were smaller than those exploited by the fishery and were significantly different among the zones. Abundance of *H. scabra* monitored on permanent transects on May, September and March 1994 and June 1995 was not significant but species diver-

sity was significantly reduced. The presence of only one high value species, *H. scabra*, on the reef flat would continue to place pressure on this species.

Reproduction of *H. scabra* was studied over a one-year period using histological techniques to determine the reproductive cycle and size at first sexual maturity for possible inclusion into a biologically-oriented management regime. There was a seasonality in spawning, from November to January, which is consistent with other studies carried out in Papua New Guinea. Size at first sexual maturity was estimated to be 14 cm and is consistent with other studies carried out in Papua New Guinea. Observations on spawning found that males tended to spawn earlier than females. A continuous stream of spermatozoa was standard for males but females released oocytes in cycles of about 5 minutes.

Movement is an important consideration in sea cucumber biology and management. The burrowing behaviour and directional movement were investigated in *H. scabra*. Burrowing behaviour was significantly different between high and low tide but was suspected to have been caused by spawning rather than tide. Movement was not random. Water appears important as a hydrodynamic fluid which is used in locomotion by *H. scabra*.

Three management regimes based on this study were recommended for implementation in management. These are a closed season during the spawning season from November to January, a variable Total Allowable Catch of 49 tonnes based on the estimated Maximum Sustainable Yield, and a size limit of 21 cm which is set above the size at first sexual maturity of 14 cm because it is economically desirable and biologically acceptable.

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