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PROCEEDINGS OF THE "FRIENDS OF ECHINODERM, N.A." JUNE 1-2, 1989 DAUPHIN ISLAND, ALABAMA

In June 1989, approximately 75 scientist, whose research is based on some aspect of the biology of echinoderms, met to discuss current research efforts and present findings. The meeting attracted participants from as far away as California, Canada, Japan, Puerto Rico and the northeast U.S. This meeting will become an annual event to be held during the year before the triannual "International Echinoderm Conference" which meets in Japan during 1990. The next meeting for the North American group will be in 1992 at the University of California at Santa Cruz, and hosted by Dr. J.S. Pearse.

The 1989 meeting produced the following abstracts as a result of either oral or poster presentations. The abstracts were reviewed by the four member organizing committee.

ANDROGEN METABOLISM IN SOMATIC AND GAMETIC TISSUES OF THE SEA STAR *Asterias vulgaris*

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ABSTRACT: Body tissues of *Asterias vulgaris* were obtained in the fall during early stages of gametogenesis. Microsomal preparations of male and female pyloric caeca, body wall, testis and ovary were incubated with radioactive androstenedione. Testis, ovary, and body wall homogenates were incubated for eight hours; pyloric caecal homogenates were incubated for two hours. Radioactive steroid products were determined via TLC and recrystallization to constant specific activity. Highest rates of androstenedione conversion were found in the pyloric caeca. In male and female pyloric caecal homogenates androstenedione was converted primarily to testosterone and also to 5α-androstane-3β-17β-diol and, preliminarily, 5β-androstane-3β-17β-diol; both are considered potent androgens in vertebrates. It is not known whether high levels of androgen metabolism in the pyloric caeca are related to steroid catabolism associated with digestion, or production of metabolically active steroids. In body wall, testis and ovary homogenates androstenedione was converted primarily to testosterone, and to a lesser extent, to androstanedione and epiandrosterone, indicating high 17β-hydroxysteroid dehydrogenase (HSD) activity relative to 5α-reductase and 3β-HSD. Highest rates of androstenedione conversion and product accumulation occurred in the testes. No estrogens were detected by TLC, however, preliminary RIA has detected significant levels of estradiol in male and female gonads and pyloric caeca (1.1-1.9 ng/g tissue) with highest levels noted in ovaries. Qualitative and quantitative differences in androgen metabolism found in somatic and gametic tissues of *Asterias vulgaris* may be related to tissue-specific regulation of cellular metabolism. Supported by NSF DCB-8711425 and NATO 86/413.

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THE EFFECTS OF A POLYACRYLAMIDE BASED POLYMER AND POLYACRYLATE ON EMBRYOS AND GAMETES OF *Arbacia punctulata*

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ABSTRACT: Polyacrylamide and polyacrylate based polymers are used as antiscalant chemicals in water treatment processes. Because these treatment waters are returned to natural waters, the environmental impact of these substances is of concern. The toxicity of these polymers was determined by examining their effect on oxygen uptake of *Arbacia punctulata* embryos and gametes. In addition, the development of embryos exposed to these polymers was monitored. The respiration of sperm exposed to a polyacrylamide based polymer was drastically reduced. Additionally, embryos that were cultured in the presence of this polymer fail to reach the mature pluteus stage with complete spicules. Sperm cells exposed to polyacrylate show no change in respiration compared to control cells. However, embryos exposed to polyacrylate do show development defects with many embryos failing to reach the pluteus stage. At high concentrations (1.0 mg/ml) of the polyacrylamide based polymer, embryogenesis is halted at the unhatched blastula stage. Continuation of toxicity studies of water treatment polymers seems prudent, as many of these water treatment polymers are represented to be non-hazardous.

PRELIMINARY ELECTROPHORETIC CHARACTERIZATION OF HISTONE PROTEINS ISOLATED FROM THE PYLORIC CAECA AND TESTES OF THE SEA STAR *Asterias Vulgaris*

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ABSTRACT: Histones were acid extracted/ethanol precipitated from the pyloric caeca and testes of the sea star *Asterias vulgaris*. Extracted samples were electrophoresed, with calf thymus histone (Sigma) as the standard, on acidic 15% polyacrylamide gels. Gel system I contained 5 mM Triton X-100 and 6 M urea. Gel system II contained 2.5 M urea and no Triton. Proteins were stained with 0.2% amido black for visualization. In gel system I, nucleosomal histones (H2A, H2B, H3 and H4) from pyloric caeca exhibited mobilities similar to calf thymus histones. Subfraction H1 was not apparent in this system. Gel system II provided a more conclusive assessment of the mobilities of subfraction H1. Preliminary results indicate that H1 of pyloric caeca migrated at a rate comparable to that of the standard. In contrast, the H1 subfraction from testes migrated slightly slower than calf thymus H1, and may represent tissue-specific differences in structure and DNA binding properties of histone H1. The electrophoretic mobility of testicular H1 is similar to that reported for sperm or testis-specific H1 subfractions from other species. These preliminary results are consistent with the conservative nature of histone proteins and studies of histones from other sea star species.

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MECHANISMS CONTROLLING INTESTINAL GROWTH IN THE SEA URCHIN *Lytechinus variegatus*

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ABSTRACT: The mass of the total gut of *Lytechinus variegatus* was found previously to vary in size depending on the nutritional condition of the individual. Differences in the stomach and large intestine with feeding were not reported. *Lytechinus variegatus* (50-90 g) were collected from Port St. Joe Bay, Florida in December, 1988, and held in aerated 80 l aquaria (32 ppt salinity, 22°C) for 90 days without feeding. Individuals were separated randomly into 3 groups. One group was fed an *ad libitum* diet of agar supplemented with high protein fish meal (FM), another group was fed an *ad libitum* diet of Noble agar (Difco), and the final group was starved. Six individuals were removed from each treatment at 0, 7, 14 and 28 days and dissected. The mass of the stomach and large intestine increased within 7 days in individuals fed the FM diet. At the end of one month the weight of the total gut of FM individuals was 2.6 fold higher than in starved individuals. Gonad weight increased significantly in FM individuals at the end of 14 days and indicates the storage of nutrients in the gonads. The time course of change in mass of the gut of FM individuals suggests that nutrients are accumulated first in the stomach, followed by the large intestine and then the gonads. The amount of DNA increased and DNA concentration decreased in the stomach and large intestine of fed individuals during growth. The time course of growth in relation to DNA content indicates that the stomach and intestine undergo hypertrophic growth prior to hyperplastic growth. Levels of the diamine putrescine increased in the stomach and large intestine by day 7 and may be related to the production of polyamines necessary for cell division. The significant increase in gut size of individuals fed Noble agar at the end of one month suggests that urchins can utilize agar as a nutrient source.

THE ALLOMETRY OF PLATE SIZE AND NUMBER IN THE SEA URCHIN *Strongylocentrotus drobachiensis*

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ABSTRACT: The following data have been obtained from a collection of sea urchins, *S. drobachiensis*, from St. Andrews, New Brunswick: test diameter, height, dry weight, and ashed weight (partitioned as spines, test plates and lantern). The plates were then spread out flat, retaining their relative positions within columns, so that they could be counted. From each specimen, all of the plates from both columns in one ambulacrum and an adjacent interambulacrum were entered into a computer by means of a digitizing tablet. For this purpose, ambulacral plates were treated as rectangles, interambulacral plates as pentangles. The length (meridional) and width (circumferential) of each plate was computed. Least squares regression analyses of test dimensions, plate sizes and plate numbers have been used to predict these variables for any size of urchin. These data may be used to generate a computer model simulating echinoid growth.

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A PRELIMINARY STUDY OF THE EFFECT OF PHOTOPERIOD ON GAMETOGENESIS IN THE TROPICAL SEA URCHIN *Eucidaris tribuloides*

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ABSTRACT: ***Eucidaris tribuloides*** **collected from the Florida Keys in June 1988 were divided into four experimental photoperiod treatments (in-phase; six months out-of-phase; fixed short day L:D, 10:14 h; fixed long day L:D, 14:10 h), held at constant temperature, and fed an *ad libitum* diet of 5% protein agar blocks. Ten individuals were sampled every three months from each of the photoperiod treatments, dissected, and gonadal maturity ascertained. Ripe individuals were considered those with oozing gonads, and active sperm or abundant mature ova. Individuals held at ambient photoperiod (in-phase) reached maturity in the fall of 1988, similar to populations in the Florida Keys. However, individuals held six months out-of-phase still had immature gonads. By the spring of 1989 this pattern had reversed, with in-phase animals having immature gonads while the out-of-phase individuals had oozing gonads filled with active sperm or mature ova. Individuals held under fixed long days generally had immature gonads, while individuals held under short days had mature gonads, suggesting that short days are necessary to trigger gametogenesis. Gametogenesis is clearly under photoperiodic control in *E. tribuloides*. This is the first demonstration of photoperiodic control of reproduction in a tropical echinoderm, and indicates that even small annual incremental changes in day length can regulate gametogenic processes in marine invertebrates.**

LOSS OF SECONDARY PRODUCTION BY A BURROWING OPHIUROID VIA PARTIAL PREDATION

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ABSTRACT: In North Inlet, South Carolina, the amphiurid ophiuroid *Microphiopholis gracillima* autotomizes portions of its disc (integument, gut, gonads) and arms when attacked, then regenerates the lost parts. Disc loss constitutes 12-25%, each arm 14-18% of the tissue weight of the animal. In the field, 18-82% of the animals are regenerating the disc, 91% are regenerating at least one arm, and 54% of all arms show signs of predation. Fifty-seven percent of all depredated arms lose only the distal third, and the whole arm is lost only 29% of the time. Rate of regeneration is temperature dependent, and discs regenerate faster than arms. Per arm regeneration rate is constant, so animals which lose more than one arm in a single predation event regenerate more tissue per unit time. Calculations using data on tissue weights, monthly frequencies of animals regenerating arms and/or discs and temperature-specific regeneration rates indicate that a population loses about 21% of its standing crop per year to partial predation.

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A SYNTHETIC BIOMATERIAL MADE FROM AN EXTRACT OF HOLOTHURIAN BODY WALL WHICH RETAINS THE ION-DEPENDENT MECHANICAL PROPERTIES OF THE "CATCH" MECHANISM

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ABSTRACT: Recent studies of the swelling behavior of holothurian body wall "catch" connective tissue (Eylers and Greenberg, *J. exp. Biol.* 143, 71-85, 1989) have demonstrated that: 1) a tenfold increase in the ratio of calcium to sodium ions (.04 to .40) in a solution of mixed chloride salts (ionic strength 0.6) will activate the "catch" mechanism *in vitro*, and 2) the "catch" can be reversed by bathing the tissue in a low calcium, high sodium solution. When placed in a pure sodium chloride solution (1:4;w:v), the body wall tissue dissolves, forming an opaque, white, mucoid suspension. Upon dialysis against an isotonic calcium chloride solution, the suspended material flocculates and falls to the bottom leaving a clear solution above. Droplets of the sodium chloride suspension falling through a calcium chloride solution form gel beads which sink to the bottom, do not stick to each other, and retain their integrity during subsequent handling. If the beads are returned to a sodium chloride solution, they dissolve. These observations indicate that holothurian body wall can be dissociated and reformed into a material which retains the essential ion-dependent characteristics of the "catch" mechanism. Such a material may prove useful in studying the physical chemistry of the mechanism and in the production of novel synthetic biomaterials.

GONAD ALLOMETRY AND THE SIZE AT FIRST REPRODUCTION: PROBLEMS WITH DATA ANALYSIS AND INTERPRETATION

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ABSTRACT: Analysis and interpretation of changes in gonad weight (G) relative to total weight (T) as animals grow is complicated by the fact that the gonad does not begin to develop until animals have achieved some minimum size or age. The standard allometry equation, $G = aT^{\beta}$ must be modified to include the size T_0, when the gonads begin to develop: $G = a(T - T_0)^{\beta}$. Failing to estimate T_0 may lead to substantial errors in interpretation of the allometry of gonad development; an apparent increase in relative size of the gonad during growth may, in fact, be a relative decrease as shown by *Diadema setosum* from Zanzibar.

SHORT TERM EFFECTS OF TEMPERATURE ON FEEDING, ORGANISMAL ACTIVITY AND SURVIVAL OF THE CARNIVOROUS, TROPICAL SEA URCHIN *Eucidaris tribuloides*

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ABSTRACT: Individuals of *Eucidaris tribuloides* (n = 20/treatment) were held at 20°C for two months, placed into individual polyethylene containers, and exposed to three temperature treatments (10, 20 and 30°C). Individuals were fed agar blocks impregnated with 5% fish meal. Feeding rates, righting times and survival were measured over an eight week period. Individuals held at 10°C had very low feeding rates (<0.05 g/day), low organismal activity (righting time >600 sec) and experienced complete mortality after 30 days. Sea urchins held at 20°C ingested an average of 0.56 g/day, had mean righting times of 80 sec, and experienced 10% mortality after 38 days. Sea urchins held at 30°C had similar feeding rates and righting times when compared with the 20°C group. However, individuals experienced 50% mortality at 30°C after 38 days. No temperature acclimation occurred in the 10°C group. Individuals held at 30°C showed an initial depression in feeding (2 days), then complete acclimation with a return to feeding levels comparable to the 20°C group. Although individuals held at 30°C showed complete acclimation, mortality occurred throughout the course of the experiment. *E. tribuloides* appears to be able to withstand short term (1-7 days) exposure to temperature extremes, but suffers significant mortality if temperature extremes persist longer than this period.

NUTRIENT TRANSLOCATION DURING EARLY DISC REGENERATION IN THE BRITTLESTAR *Microphiopholis gracillima* (STIMPSON) (ECHINODERMATA: OPHIUROIDEA)

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ABSTRACT: *Microphiopholis gracillima* can autotomize and then regenerate the autotomized central disc cover, including integument, gut, and gonads. Experiments were carried out to determine the relative importance of internal nutrient reserve translocation and exogenous nutrient uptake during the regeneration process. Approximately 60% of the dry body weight of *M. gracillima* is organic material. Intact animals held in natural seawater did not change significantly in weight, caloric content, or relative concentration of protein, carbohydrates, or lipids for 3 weeks. Intact animals held in artificial seawater devoid of nutrients for 3 weeks lost weight and caloric content. Rate of loss was rapid initially, but slowed after approximately 8 days. Animals regenerated in natural seawater lost weight initially, then regained the lost weight. Animals regenerated in artificial seawater lost weight constantly and at a higher rate than either the artificial seawater control or natural seawater regenerated animals. All weight losses were attributable to significant changes in protein and carbohydrate fractions of the organic body component. The lipid fraction and ash components did not change significantly in any treatment. *M gracillima* appears to be adapted to regenerate the lost disk rapidly, even under food deprivation conditions.

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PRELIMINARY NOTES ON DEPTH DISTRIBUTION, SUBSTRATE TYPE, AND REPRODUCTIVE MODE OF OFFSHORE ECHINODERMS FROM THE NORTHERN GULF OF MEXICO

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ABSTRACT: Dredging cruises conducted 25-50 km. south of Pensacola, Florida in Oct., Nov., Dec. (1988), and Feb., Apr., and May (1989) have resulted in the collection of 30 species of echinoderms representing 4 classes and in excess of 12 families. Distribution of the differing species is strongly associated with substrate type and depth. Five asteroids, 2 ophiuroids, and 3 regular echinoids are common inhabitants of coarse sand and broken shell substrate in the 30-35 m depth range. Three asteroids and 2 irregular echinoids are characteristic of the soft clastics at this depth. At 90-95 m, there is a distinct increase in species numbers and kinds which appears associated with a unique habitat composed of algal cemented limestone nodules (5-10 cm in diameter) and coralline red algae. From this habitat, we have recorded 10 asteroids, 2 gorgonocephalid ophiuroids, 4 regular echinoids, 3 holothuroids, and one crinoid species. A few miles away, on a hard packed sand bottom, there is a large population of an irregular echinoid at 90-95 meters depth. On the basis of egg size, egg buoyancy, and fecundity, the predominant mode of reproduction appears to be planktotrophy (6 of 10 species examined). Three of the remaining four species examined produce large buoyant yolky eggs and appear to be pelagic lecithotrophs. The ophiuroid *Astroporpa annulata* appears to brood its large embryos. Moreover, juveniles have been found attached to the aboral side of the central disc of adults in what may be a unique brooding habit.

RELATIONSHIP BETWEEN THE BIPINNARIA AND THE BARREL-SHAPED LARVAE IN *Astropectinidae* (ASTEROIDEA)

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ABSTRACT: Barrel-shaped larvae occur in three species of Astropectinidae: *Astropecten latespinosus*, *Astropecten gisselbrechti*, and *Ctenopleura fisheri*. The principal features of organogenesis are similar in both bipinnaria and barrel-shaped larvae, but some features are different. The barrel-shaped larvae lack ciliary bands, projections of the larval arm, and a mouth. It is probable that bipinnaria and barrel-shaped larvae are formed from small and large eggs, respectively. Thus the barrel-shaped larvae are more lecithotrophic than the bipinnaria larvae and are modified forms of the bipinnaria.

ALLOMETRY OF LANTERN FORCES IN SAND DOLLARS

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ABSTRACT: During the course of feeding, sand dollars use the five-toothed Aristotle's lantern to bite in-coming particles. Radial forces along the teeth result from tangential forces created by contraction of the inter-pyramidal muscles. The lantern has been modeled as a thick-walled cylinder. According to this model, the magnitude of the forces generated is dependent upon the internal area of the pyramid and the internal and external radii of the cylinder or lantern:

$$F = S^*A^*[(re^2 - ri^2)/(re^2 + re^2)]$$

where F = the radial force in N, S = maximum stress in Nm^{-2}, A = area of pyramid tip in m^2, and re and ri = the internal and external radii of the cylinder (respectively) in m. In the present study lantern allometry has been used to estimate the biting forces of thirty specimens each of *Echinarachnius parma*, *Mellita isometra* and *Leodia sexiesperforata*, from juvenile to adult sizes. *Leodia sexiesperforata* was found to have the smallest lantern of the three species studied, however there is an increase in its relative size during growth. The lantern sizes for the three species converge and are similar in adult specimens. The term relating the squares of internal and external radii was found to be constant for all three species (1.119 ± 0.032). In each of the species, the calculated bite forces increase geometrically with test diameter. Forces are almost identical for *E. parma* and *M. isometra* ($F = 0.002 * D^{1.9}$) and smaller for *L. sexiesperforata* ($F = 0.003 * D^{1.7}$).

CHEMICAL DEFENSE IN ANTARCTIC LECITHOTROPHIC ECHINODERM LARVAE

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ABSTRACT: The hypothesis that echinoderm eggs and larvae contain chemical defenses was examined in sixteen species of antarctic echinoderms (12 asteroids, 2 echinoids and 2 holothuroids). Agar pellets either containing 2% fish meal and 5% larval tissue (experimental) or 2% fish meal alone (controls) were offered in a random sequence to planktivorous marine fish (*Fundulus grandis*). Feeding responses were categorized as accepted (ingested), partially rejected (mouthed several times then rejected) and totally rejected (ignored). Of the sixteen echinoderms tested, four asteroid larvae caused deterrence. The lecithotrophic larvae of *Diplasterias brucei* and *Porania antarctica* caused 100% rejection. The lecithotrophic larvae of *Perknaster fuscus antarcticus* and *Notasterias armata* caused 97% and 23% rejection, respectively. The other twelve species were not discriminated against. However, the presence of chemical deterrents in these species should not be ruled out, as some chemical deterrents may degrade quickly. Antarctic echinoderms with lecithotrophic embryos are known to have low fecundity and slow development and may be subject to long periods of predation. These studies suggest that chemical defenses may play a significant role in preventing predation of antarctic lecithotrophic echinoderm larvae.

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DIGESTION, RESPIRATION, AND MOVEMENT OF *Eucidaris tribuloides* (LAMARCK) (ECHINODERMATA: ECHINOIDEA) FED PLANT OR ANIMAL MATERIAL

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ABSTRACT: ***Eucidaris tribuloides*** **were maintained in individual containers and fed prepared foods containing either plant or animal meals of known, uniform compositions. Feeding rates were higher on animal meal (0.368 ± 0.030 g per individual per day; $\bar{x}$ ± 1 SE) than on plant meal (0.190 ± 0.021 g per individual per day). Feeding rates on both foods decreased slightly over the time course of feeding. Rates of fecal production did not differ with food type but did increase over time with feeding. Fecal production stopped within 3 days of cessation of feeding for both animal and plant fed individuals. Only 0.013 ± 0.013 g of plant food and 0.005 ± 0.004 g of animal food was retained in the gut at the time defecation ceased. Throughput rate on either food was 2 days. Oxygen consumption was higher for the individuals fed the plant food (2.516 ± 0.187 ul per hour) than those fed the animal food (2.214 ± 0.181 ul per hour). Oxygen consumption increased over time with feeding with both foods. Gut indices increased with feeding but were not significantly ($p = \leqslant 0.05$) different for individuals fed either food. Activity coefficients were significantly lower for individuals not fed but did not differ for individuals fed a protein or carbohydrate rich food. Rates of movement were highest for individuals fed a protein diet, lowest for those not fed, and intermediate for those fed a carbohydrate diet. Supported by the Bloomsburg University Alumni Fund and Faculty Development Grants from Bloomsburg University and the State of Pennsylvania.**

EFFECTS OF QUALITY OF DIET ON FEEDING RATES, FECAL PRODUCTION AND GRAVIMETRIC ABSORPTION EFFICIENCIES OF THE TROPICAL SEA URCHIN *Eucidaris tribuloides*

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ABSTRACT: ***Eucidaris tribuloides*** **(n = 10/treatment) were held in individual polyethylene containers with recirculating sea water at 20°C and proffered *ad libitum* amounts of either low (5% agar) or high (5% agar with 5% fish meal) quality diets. Feeding rates were variable. Nonetheless, individuals fed the low quality diet generally ingested more food than individuals fed the high quality diet. The mean amounts of food ingested over the 30 day period were 142.2 mg/indiv day and 112.6 mg/indiv/day in the plain agar and fish meal agar groups, respectively. Individuals fed the low quality diet produced less feces (24.3 mg/indiv/day) than individuals fed the high quality diet (68.9 mg/indiv/day). Gravimetric absorption efficiency was much higher in individuals fed the low quality diet throughout the entire experimental period. Feeding rates of this carnivorous sea urchin reflect the decreased necessity of processing large amounts of low quality food. It is hypothesized that in order to obtain maximum utilization of available nutrients, *Eucidaris tribuloides* fed low quality diets retain ingested food, whereas sea urchins fed high quality diets process foods more rapidly, producing more feces. These results indicate that the quality of the diet can significantly affect aspects of nutrition in this carnivorous sea urchin.**

SPATIAL DISTRIBUTION PATTERNS OF THE SYMPATRIC BRITTLESTARS *Hemipholis elongata* AND *Microphiopholis atra* IN EASTERN MISSISSIPPI SOUND

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ABSTRACT: ***Hemipholis elongata*** **and** ***Microphiopholis atra*** **exhibited differential distributions at 3 stations in eastern Mississippi Sound. In addition, each species was found to occur in dense monospecific patches. This differential distribution could not be explained by sedimentological or physical conditions. The role of interspecific competition was tested in uniform microcosms at treatment levels of 50, 100 and 150 individuals/m². Treatments consisted of microcosms containing one species (control treatments) and treatments containing both species (interaction treatments). Results indicated** ***M. atra*** **separated into monospecific patches at a density of 100 individuals/m² while** ***H. elongata*** **did so at 50 individuals/m². The order of introduction into interaction treatments strongly affected the results. The differential distributions of both species seem best explained by preemptive competition rather than interspecific competition. The recruitment patterns showed that the initial settlement of** ***H. elongata*** **was passive. Observations were less clear in the case of** ***M. atra*****. The distribution of juveniles was closely associated with that of adult conspecifics suggesting that enhanced survivorship is experienced by those recruits who settle within or migrate into adult conspecific patches.**

STUDIES ON THE EFFECTS OF THE SEA URCHIN *Lytechinus variegatus* IN *Thalassia testudinum* SEAGRASS MEADOWS IN ST. JOSEPHS BAY, FLORIDA.

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ABSTRACT: Sea urchin herbivory has been frequently demonstrated to control kelp distribution but its role in limiting the distribution of seagrasses is poorly understood. Experiments with urchins (*Lytechinus variegatus*) show that densities as low as 40 individuals/m² in fall, 1988 and 20 individuals/m² in winter, 1989 were sufficient to overgraze seagrass habitats (*Thalassia testudinum*) in northwestern Florida. Field surveys show maximum densities in an urchin front reached 132 individuals/m². These results indicate that overgrazing of seagrass may be more common than previously reported, especially since predation rates on tethered sea urchins were low (ranging from 0-3%/day).

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ESTIMATING LANTERN FORCES IN *Clypeaster rosaceus*: OR, THE BISCUIT BITES BACK

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ABSTRACT: The teeth of Aristotle's lantern are drawn together by the action of the comminator or inter-pyramidal muscles. In conjunction with development of a biomechanical model of the lantern, we have made direct measurements of the biting force of the sea biscuit, *Clypeaster rosaceus*. Two methods were used. In the first, we offered live specimens selected pieces of standard glass tubing (capillary pipets and micro-cells), and simply recorded which ones they were able to fracture. In the second, we offered the specimens a length of electricians solder to bite and subsequently measured the depth of the tooth marks. Both methods were calibrated by actual force measurements. Isolated teeth were cut and glued to the platens of a strain gage stress testing device. The teeth were aligned as nearly as possible to their mode of action in the live specimen. The forces required to break the chosen glass tubing were then measured. Similarly, the solder technique was calibrated by using the stress tester to "bite" the solder with a series of known forces. Particles similar to those occurring in the food grooves of sea biscuits were selected from natural sand and broken in the stress tester. Estimated lantern forces are well in excess of forces required to fracture food material. Maximum stress in the muscle was determined to be 6.58×10^5 N m^{-2}. Using this stress value, the model allows prediction of forces in lanterns of different sized specimens.

FEEDING AND DIGESTION OF PREPARED PROTEIN AND CARBOHYDRATE RICH DIETS BY *Strongylocentrotus droebachiensis* (O.F. MULLER) (ECHINODERMATA: ECHINOIDEA)

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ABSTRACT: *Strongylocentrotus droebachiensis* were maintained in individual containers and fed prepared agarose foods containing meals of known, uniform compositions. Feeding rates were similar on protein rich foods (2.119 ± 0.140 g per individual per day; $\chi \pm 1$ SE) and carbohydrate rich foods (2.152 ± 0.183 g per individual per day). Daily rates of ingestion did not vary significantly ($p>0.05$) over 12 days of feeding on either food. Rate of fecal production (1.45 ± 0.096 g per individual per day) did not differ with food type or over time. Fecal production dropped sharply after cessation of feeding. However, *ca.* 0.1 g of feces per individual per day continued to be produced after 14 days without food. After 14 days with no food 0.084 ± 0.073 g of protein food and 0.017 ± 0.041 g of carbohydrate food was retained in the gut. Throughput feed rate on either food was *ca.* 2 days. However, considerable mixing and retention of food occurred in the gut. Marked feces continued to be collected in small amounts 20 days after marked food was proffered. Gut indices did not change with feeding on the high carbohydrate food but decreased with feeding on the high protein food. Supported by Faculty Development Grants from Bloomsburg University and the State of Pennsylvania.

THE RELATIONSHIP BETWEEN THE MAJOR AND MINOR RADII AND THE INTERNAL ANATOMY OF ASTEROIDS

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ABSTRACT: Hyman (1955) noted that although asteroids could have a pentagonal or stellate disc, the typical form has a central disc which passes insensibly into the arms. She noted that taxonomic descriptions of asteroids customarily state the measurements of R (major radius) from the disc center to the arm tip, and r (minor radius) from the disc center to the edge of the disc between two arms. Hyman gave a second definition of the disc that has an anatomical basis: the disc is that portion of the body that contains the cardiac stomach. This anatomical definition of the disc had been given by Bather (1900), Chadwick (1923), and Cuenot (1948). These definitions imply that r gives the radius of the stomach and R − r gives the length of the arm. The latter would give an estimation of the potential size of the gonads and pyloric caeca. It is readily apparent that a problem exists with this simplistic approach for those forms with a pentagonal or stellate disc, but it is less well known that a problem exists for those forms with the more "typical" central disc as described by Hyman. Rathbun (1887) noted that the arms of *Heliaster* spp. are "free" for less than half of their length, clearly pointing out that much of the arm length is incorporated into the central portion of the body. The situation is similar in *Acanthaster*. Clark (1907) extended these observations, noting that the proximal coalescence of the arms is just as extensive in *Pisaster ochraceus* as in *Heliaster*. consequently, the actual arm length is greater than R − r, and the potential length of the pyloric caeca and gonads is greater than that calculation indicates. The fusion of the arms may be for protection of the origin of the gonads and pyloric caeca from predation, or of the cardiac stomach when it is extruded for feeding. Fusing the proximal parts of the arms would increase the protected area for the stomach. Fusing the proximal parts of the arms may be an alternative to forming a pentagonal or stellate disc form. All reduce the length of the free portion of the arm.

THE EFFECTS OF INTRACELLULAR CATION CONCENTRATIONS ON THE SPECIFIC ACTIVITIES OF GLUCOSE-6-PHOSPHATE DEHYDROGENASE AND PYRUVATE KINASE IN THE PYLORIC CAECA, TUBE FEET AND GONADS OF *Luidia clathrata* (Say) (ECHINODERMATA: ASTEROIDEA)

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ABSTRACT: Exposure of *Luidia clathrata* to different salinities results in adjustments in the level of intracellular inorganic ions as part of the animal's cell volume regulatory mechanisms. Unlike changes in free amino acids, ionic adjustments may have profound effects on the activities of cytosolic enzymes. The effects of intracellular cation concentrations at 15, 25 and 35‰ on the specific activities of pyruvate kinase and glucose-6-phosphate dehydrogenase were examined in several tissues of *L. clathrata*. Pyruvate kinase activity was highest in the 15‰ assay buffer and lowest in the 35‰ assay buffer in all tissues examined. The specific activity of glucose-6-phosphate dehydrogenase was significantly

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higher ($p<0.05$) in the 15‰ buffer and significantly lower ($p<0.05$) in the 35‰ buffer than the specific activity measured in the 25‰ buffer for both the gonads and tube feet of *L. clathrata*. Specific activities for both enzymes were highest in tube feet. These results indicate that all cytosolic enzymes are not affected to the same degree when changes occur in the levels of inorganic ions in tissues of *L. clathrata*. The capacity for echinoderms to tolerate low salinities does not appear to be limited by a decrease in the specific activity of certain metabolic enzymes.

A COMPARISON OF *Clypeaster durandi* CHERBONNIER TO OTHER CARIBBEAN-GULF OF MEXICO *Clypeaster* SPP.

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ABSTRACT: ***Clypeaster durandi*** **was described by Cherbonnier (1959) from four specimens collected from 105 meters SW adjacent to French Guiana, S.A. Cherbonnier made comparisons to *C. ravenelii*, but not to any of the other fossil or extant Caribbean species of *Clypeaster*. I have examined MNHNP EcSc 8202 a syntype originally seen by Cherbonnier. The test is flattened with rounded ambital margins which account for about 25% of the outer aboral surface area before rising steeply to a rather sharp apex in contrast to the thickened outer margin and "domed" apical shape of *C. ravenelii*. Although the petals are open distally (in opposition to Cherbonnier's description), they are not as open as *C. cyclopilus*, *C. euclastus*, or *C. ravenelii*. The color in life was dark green whereas *C. cyclopilus* and *C. ravenelli* are a very light green, and *C. euclastus* was rose purple. At the present time, we must consider *C. durandi* as a valid species with limited distribution analogous to *C. cyclopilus*, *C. euclastus*, and *C. lamprus*. Its position in relation to other members of the group remains uncertain because it shares characters with members of the "closed petal" group (*C. chesheri*, *C. prostratus*, and *C. subdepressus*) and the "closed petal" group described above and diagramed in Hopkins (1988). The development of a cladogram must await a refinement of characters associated with (a) Petal design, (b) Test morphology, (c) Oral surface areole distribution, (d) Anal position, and (e) Pedicellaria and spine morphology along with a consideration of outgroup characteristics of fossil *Clypeaster* spp. from the Caribbean.**

ACTIVITIES OF HEXOKINASE, PHOSPHOFRUCTOKINASE AND PYRUVATE KINASE IN THE BODY WALL, PYLORIC CAECA AND TUBE FEET OF *Asterias vulgaris*: EVIDENCE OF BODY WALL AS A MAJOR SOURCE OF GLYCOLYTIC ACTIVITY

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ABSTRACT: Four adult individuals were collected in August prior to initiation of gametogenesis. Specific activities of glycolytic enzymes were determined as functions of wet weight and cytosolic protein. The average gravimetric distributions of the organs were calculated (wet organ weight/wet animal weight: body wall 55%; coelomic fluid 23%; pyloric caeca 16%; tube feet 3%; other 3%) to determine the total enzyme activities per organ. HK and PK activities were significantly higher than PFK activity in all organs studied. The highest HK activity (3.75 umole/min/gww) was found in the pyloric caeca. Despite low PFK activity, the highest PK activity (6.34 umole/min/gww) as well as the highest total PK activity (101 umole/min) were found in the pyloric caeca. These results suggest that a high concentration of a glycolytic intermediate, probably glyceraldehyde-3-phosphate derived through lipid catabolism, enters the pathway after PFK. Tube feet exhibited the highest PFK and PK activities (3.65 nmole/min/mg protein and 104 nmole/min/mg protein, respectively). This may reflect the high energetic requirements of the tube feet. As a function of wet weight, activities of HK, PFK and PK were minimal in the body wall, reflecting the low organic content of the organ. However, the highest total PFK activity (657 nmole/min) and highest HK activity (73.5 nmole/min/mg protein) suggest the importance of the body wall in the overall glycolytic activity of the organism.

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