Table 2. Effects on Vegetative Growth and Oogonial Formation of the Addition in all Possible Combinations of Four Additives to a Fortified Basal Medium

(Data listed are averages of triplicate determinations per treatment)

| Fortified basal medium* plus: | Mycelium weight (mg) 6 days | Mycelium weight (mg) 21 days | No. of oogonia 21 days |
|---|---|---|---|
| *X*—no additive control | 73 | 77 | 313–*I*§ |
| Mo—molybdenum† | 59 | 78 | 9–*I* |
| Cu—copper† | 55 | 80 | 0 |
| Mn—manganese† | 58 | 93 | 0 |
| Zn—zinc† | 58 | 64 | 0 |
| Cu, Mo | 67 | 83 | 19–*I* |
| Mn, Mo | 70 | 93 | 713–*M* |
| Mn, Cu | 56 | 90 | 0 |
| Zn, Mo | 65 | 61 | 0 |
| Zn, Cu | 66 | 60 | 0 |
| Zn, Mn | 104 | 86 | 3,947–*M* |
| Mn, Cu, Mo | 52 | 90 | 0 |
| Zn, Cu, Mo | 61 | 60 | 0 |
| Zn, Mn, Mo | 107 | 86 | 2,990–*M* |
| Zn, Mn, Cu | 106 | 85 | 3,570–*M* |
| Zn, Mn, Cu, Mo | 104 | 87 | 3,483–*M* |
| H.S.D. levels‡ <05 | 13 | 6 | 717 |
| <01 | 15 | 7 | 843 |

* Basal medium fortified with cholesterol, thiamine, calcium, and iron at concentrations listed in Table 1.
† Added at the concentrations and in the salt forms listed in Table 1.
‡ Honestly significant test between any two means (method of Tukey (ref. 4)) at the 1 per cent and 5 per cent confidence levels.
§ *I*, Immature; *M*, mature.

and 6-day mycelial weights than any of the media not containing both of these metals. The control and the manganese–molybdenum treatment are the only media which produced an appreciable number of oogonia without having both zinc and manganese present. By factorial analysis, both the latter metals were found to produce highly significant main factor effects. For vegetative growth, zinc had the greatest stimulatory effect; on interaction the effects of zinc and manganese tended to be additive. Copper and molybdenum showed no significant main factor effects. However, copper interacted significantly with the other three metals to inhibit vegetative growth, although it showed no effect on oogonial formation. As for the previous experiment, the 21-day mycelial weight results were not interpreted because of extensive autolysis.

Fothergill and Hide[5], working with four other species of *Pythium*, found that calcium, iron, trace minerals and thiamine had no effect on growth (no sterol was present). We found that all these additives stimulated the growth of *P. graminicola*, whether tested with our basal medium or with the media of Fothergill and Hide. This difference is undoubtedly attributable to a difference in the requirements of the species and isolates employed. Similarly, we found that *Pythium vexans* and *P. arrhenomanes* produced oogonia on Czapek's medium plus sterol, in the absence of zinc, manganese and calcium[3]. In addition to this, Hendrix[2] found that sterols induced sexual reproduction in *Pythium periplocum* and *Phytophthora magasperma*, although his basic medium contained no zinc, manganese or calcium. It is apparent that some species of *Pythium* have much more exacting metal ion requirements for reproduction and growth than do other species.

James F. Lenney
Howard W. Klemmer

Pacific Biomedical Research Center,
University of Hawaii,
Honolulu.

Haskins, R. H., Tulloch, A. P., and Micetich, R. G., *Canad. J. Microbiol.*, **10**, 187 (1964).
[2] Hendrix, J. W., *Science*, **144**, 1028 (1964).
[3] Klemmer, H. W., and Lenney, J. F., *Phytopathology*, **55**, 320 (1965).
[4] Tukey, J. W., in *Experimental Design*, edit. by Federer, W. T. (The Macmillan Co., New York, 1955).
[5] Fothergill, P. G., and Hide, D., *J. Gen. Microbiol.*, **29**, 325 (1962).

## Protandrous Hermaphroditism in Decapod Prawns of the Families Hippolytidae and Campylonotidae

Protandrous hermaphroditism, or the changing from the male sex to the female during the growth of the same individual, is now well known in certain northern-hemisphere commercial prawns of the family Pandalidae, namely, species of the genera *Pandalus* (*P. borealis*[1], *P. danae*[1], *P. hypsinotus*[1], *P. kessleri*[2], *P. montagui*[3] and *P. platyceros*[1]) and *Pandalopsis* (*P. dispar*[1]). In the Hippolytidae, this phenomenon has been demonstrated in two European and Mediterranean species of *Lysmata*, namely, *L. seticaudata* (the first decapod in which protandry was recognized[4]) and *L. nilita*[5].

In 1959, Carlisle[6] summarized our knowledge of sex reversal in decapods, discussing the aforementioned groups and adding the burrowing axiid *Calocaris macandreae*. The latter, however, has since been shown[7] not to be a protandrous hermaphrodite, but a functional hermaphrodite throughout life. Recently I recognized protandry in the Australasian, archibenthal slope species *Campylonotus rathbunae* Schmitt and discussed the changes in secondary sexual characters involved[8]. A partially sympatric pandalid, now known as *Notopandalus magnoculus* (Bate), is not a protandrous hermaphrodite. Another species in the southern, monogeneric family Campylonotidae, the Magellanic *C. semistriatus* Bate, was also shown to be protandrous from a re-examination of the *Challenger* type material in the British Museum (Natural History).

Protandry can now be recorded in the Magellanic and Antarctic hippolytid *Chorismus antarcticus* (Pfeffer). A collection taken at Isla Navarino off the southern coast of Tierra del Fuego during the Royal Society Darwin Memorial Expedition to Southern Chile, 1958–59, consisted of males of carapace lengths 6·5–10 mm with a well-developed appendix masculina on the second pleopod, intersex specimens of 10–10·5 mm with a vestigial appendix masculina and females of 12–13 mm with no trace of this appendix.

It was also considered likely that the Indian Ocean and Australasian subantarctic hippolytid, *Nauticaris marionis* Bate, would prove to be protandrous. Preliminary examination of recent collections from Auckland and Campbell Islands in the New Zealand subantarctic, and from deep water off southern New Zealand, revealed that all the large specimens were female, mostly ovigerous, while the smaller specimens were largely male. Detailed examination, however, showed males with a well-developed appendix masculina of carapace lengths 4·5–7·5 mm, no recognizable intersex specimens and females of carapace lengths 4·5–11·5 mm. This species, then, does not show sex reversal, but mature females do reach a much larger size than males.

Protandrous hermaphroditism in decapod Crustacea appears to be restricted, so far as our knowledge goes, to two genera of northern boreal and temperate pandalids, two Mediterranean species of the hippolytid *Lysmata*, the antiboreal South American and circum-Antarctic hippolytid *Chorismus* and at least two species of the antiboreal South American and deep-water Australasian palaemonoid *Campylonotus*. The three families represented are not closely related systemically, each presently being placed in a different super-family[9], and besides the rather tenuous zoogeographic relationships (? analogous to bipolarity) no link, other than that of reproductive physiology, can be seen.

J. C. Yaldwyn

The Australian Museum,
Sydney,
New South Wales.

[1] Berkeley, Alfreda A., *Contr. Canad. Biol. Fish.*, N.S., **6** (6), 79 (1930).
[2] Aoto, T., *J. Fac. Sci. Hokkaido Univ.*, Ser. 6 (Zool.), **2**, 1 (1952).
[3] Allen, J. A., *J. Mar. Biol. Assoc. U.K.*, **43** (3), 681 (1963).
[4] Spitschakoff, T., *Z. wiss. Zool.*, **100**, 190 (1912).
[5] Dohrn, P. F. R., and Holthuis, L. B., *Pubbl. Staz. Zool. Napoli*, **22** (3), 389 (1950).
[6] Carlisle, D. B., *J. Mar. Biol. Assoc. U.K.*, **38** (3), 494 (1959).
[7] Buchanan, J. B., *J. Mar. Biol. Assoc. U.K.*, **43** (3), 729 (1963).
[8] Yaldwyn, J. C., *N.Z. Dept. Sci. Indust. Res. Bull.*, **139** (1), 24 (1960).
[9] Holthuis, L. B., *Zool. Verhand. Leiden*, **26**, 1 (1955).