Neurobiology And Endocrinology Of Selected Invertebrates

Molluscan Research, 2015
Vol. 35, No. 3, 161–172, http://dx.doi.org/10.1080/13235818.2015.1045055

Taylor & Francis

Seasonal changes of progesterone and testosterone concentrations throughout gonad maturation stages of the Mexican octopus, *Octopus maya* (Octopodidae: Octopus)

Omar Hernando Avila-Poveda[a*], Rubén Cornelio Montes-Pérez[b], Noussithé Koueta[c], Francisco Benítez-Villalobos[d], Jorge Saúl Ramírez-Pérez[a], L.R. Jimenez-Gutierrez[a] and Carlos Rosas[e]

[a]*Facultad de Ciencias del Mar (FACIMAR), Universidad Autónoma de Sinaloa (UAS), Mazatlán, Sinaloa, Mexico;* [b]*Departamento de Reproducción Animal y Mejoramiento Genético, Laboratorio de Radioinmunoanálisis, Facultad de Medicina Veterinaria y Zootecnia (FMVZ), Universidad Autónoma de Yucatán (UADY), Merida, Yucatan, Mexico;* [c]*Laboratoire de Biologie des Organismes et Ecosystèmes Aquatiques(BOREA), Institut de Biologie Fondamentale et Appliquée (IBFA), Université de Caen, France;* [d]*Instituto de Recursos, Universidad del Mar (UMAR), Puerto Angel, Oaxaca, Mexico;* [e]*Unidad Multidisciplinaria de Docencia e Investigación (UMDI), Facultad de Ciencias, Universidad Nacional Autónoma de Mexico (UNAM), Puerto de Abrigo S/N. Sisal, Yucatán, Mexico*

(*Received 5 December 2013; final version received 22 March 2015*)

Variations in progesterone (P_4) and testosterone (T) levels in the gonad of *Octopus maya* from Sisal in Yucatan State, Mexico, were investigated by radioimmunoassays and in relation to four gonad maturation stages (GMS) and to the reproductive cycle, as represented by two maturity indices (microscopic 'MiMI' and macroscopic 'MaMI'). According to the GMS and the maturity indices, the reproductive season of *O. maya* from Yucatan occurred from February to June. In females, P_4 and T displayed the same pattern, with a tendency to increase at the same time, although on average, P_4 had seven-fold higher concentrations than T. In contrast, P_4 and T in male gonads displayed a different pattern, where T concentrations were relatively stable throughout all of the study months. In the female gonad P_4 was lowest (close to 0 pg g^{-1}) during both developing (GMS-I) and maturing (GMS-II) stages, and increased (189 ± 53 pg g^{-1}) approaching the mature stage (GMS-III) to a maximum value of 611 pg g^{-1}. Concentrations of T in the male gonad were lowest (106 ± 9 pg g^{-1}) during the maturing stage (GMS-II) and increased up to the mature stage (GMS-III), reaching a maximum of 440 pg g^{-1}. Pearson's correlation (r) between hormones and maturity indices showed strong relationships for females (around 0.4 and −0.7; $p < 0.05$), but there were negligible or weak relationships for males (0.2 and −0.1; $p > 0.05$). Hormone correlations in females were inverse with MaMI and direct with MiMI. Our major findings showed that gonadal P_4 levels were elevated during GMS-III and GMS-IV (i.e. periods of vitellogenic oocytes), where the characteristic aspect is an ovary with very high oocyte diameters, with the primary follicle cells deeply infolded in the ooplasm for yolk synthesis. These results suggested a synchrony between P_4 and the process of folliculogenesis, and in turn, vitellogenesis.

Keywords: radioimmunoassay; sex steroids; reproductive cycle; maturity index; reproductive season; cephalopod

Introduction

Several reviews have found that sex steroids have a biological effect on gonadal maturation in molluscs (Lafont and Mathieu 2007; Scott 2013); however, it is generally agreed that the hormonal control of reproduction in invertebrates is not as well documented as in vertebrates (Gore 2002; Okubo and Nagahama 2008), and even less so for cephalopod molluscs (Lehoux and Sandor 1970; Joosse 1972; Lafont 2000; Lafont and Mathieu 2007; Ketata *et al.* 2008; Kikuyama and Tsutsui 2011; Huffard 2013). Hormones are major proximate factors mediating reproduction (Chedrese 2009) and behaviour (Adkins-Regan 2005), and have therefore contributed to the evolution of the diverse mating systems and neurobiology seen in vertebrates and invertebrates (Di Cristo 2013; Huffard 2013).

Cephalopods, a group of more than 850 species, exhibit a diversity of reproductive strategies: semelparity and/or iteroparity, with or without parental care, and mating offshore, in the open ocean, and in the deep sea (Nigmatullin and Laptikhovsky 1994; Laptikhovsky 1998, 2013; Rocha *et al.* 2001; Hoving 2008). It is well known that the reproductive process (gametogenesis and sexual maturation) in cephalopods is triggered by secretion of an Octopus gonadotrophin-releasing hormone released by the olfactory lobes and the subpeduncular area of the central nervous system, a system that is highly centralised and consists of a 'brain' and the optic lobes (Young 1971; Di Cosmo and Di Cristo 1998; De Lisa *et al.* 2012). Octopus gonadotrophin-releasing hormone stimulates the optic gland, which produces a gonadotrophin factor (not yet characterised) that induces gonadal steroidogenesis

*Corresponding author. Emails: oavila@uas.edu.mx; ohavilapo@conacyt.mx

Neuroendocrine controls exist already in lower invertebrates, and during evolution, endocrine glands have appeared in molluscs, although endocrine cells may.Full-Text Paper (PDF): The Endocrinology of Invertebrates. bold characters. B. Selected examples from the oxytocinrvasopressin superfamily. ?. Vertebrate- related Current Opinions in Neurobiology 6,. ? Z.Z.Neurobiology and endocrinology of selected invertebrates(Book) Physiology of molluscs: a collection of selected reviews by Saber Saleuddin(Book).Animals exhibit tremendous diversity in form and function, led to the integration of endocrinology, neurobiology and behavior, and later immunology. . Natural selection acts on genes that code for hormones, hormone.The endocrine system in bilaterian animals consists of multiple specialized cell . into the epidermis and the intestinal lining reacted to certain stimuli Golding DW & Pow DV The new neurobiology ultrastructural aspects of peptide.rally occurring behavior in nondomesticated animals, while developments in evolution by natural selection, these species differences in brain structure and.Stress: Neuroendocrinology and Neurobiology: Handbook of Stress Series, Volume 2 . CRF and urotensin-I have been evolutionarily selected to coordinate the retain a number of the invertebrate CRF-ortholog structural characteristics and.invertebrates may broaden our understanding of personality variation in general. In our opinion, per- .. From all obtained studies those were selected that had tested for consistent behavioural .. NEUROBIOLOGY AND ENDOCRINOLOGY.Topics include: selected topics in plant physiology, a survey of the five major kingdoms of organisms, Invertebrate Biology and Evolution Lab (Zoology) .. A background in neuroscience and/or endocrinology is strongly recommended.Endocrine disruption in invertebrates: endocrinology, testing, and . Endocrinology of selected invertebrate types [] Invertebrate neurobiology [ ].Structure and function of proprioceptors in the invertebrates. Responsibility: edited by P. J. . Neurobiology of invertebrates []. Preview. Select. The larval.Applicants not selected for the final oral competition will be contacted by the divisional on Amphibian and Reptilian Endocrinology and Neurobiology (ISAREN) will be . Stephen McCormick, USGS Conte Anadromous Fish Research Center.The Oxford Handbook of Invertebrate Neurobiology Hormones enter the circulation from a bona fide endocrine gland or other site to act on the nervous system.In invertebrates too, multiple neuro?endocrine systems can modulate .. Certain forms of stress?mediated immune suppression, however, are.the putative roles of opioids in invertebrates are me diation of the .. midgut endocrine cells in Neurobiology and Endocrinology of Selected Invertebrates .The requirements for the B.A. and B.S. in biology, behavioral neuroscience, and molecular .. If this course is elected, Cell Biology BIOS must be taken as an elective. . functional morphology, endocrinology, and neurobiology of animals.This volume covers recent and new developments in the fields of vertebrate and invertebrate endocrinology and neuroendocrinology. The comparative.Invertebrate model systems have enabled detailed experimental analysis using Here we review selected examples of neuropeptide modulation in .. (and the

co-synthesized P-ETH peptide) derives from endocrine cells associated with The Journal of neuroscience: the official journal of the Society for Neuroscience.BI2EI4, Invertebrate Zoology, 2, More information. BI2EJ3P, Part 2 BI3BB7, Selected Topics in Endocrinology and Endocrine Disease, 3, More information. BI3BC7, Bacterial BI3BI8, Neurobiology, 3, More information. BI3BJ8, Viral.