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SEXUAL DIMORPHISM AND SEX DETERMINATION IN BIVALVE

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Abstract: Sustaniable Animal proteins has been supplying to the world food production by Bivalve aquaculture The utility of diverse reproduction strategies in shell fish, such as the ploidy manipulation, use of gynogenesis, has created a typical case of bivalve genetic breeding. Bivalves show sexual dimorphism, protandrous hermaphrodites and this linked to multiple economic traits including growth rate and body size, and the efficient development of sex-linked genetic markers and has provided significant approaches to increase the production and value of shellfishes in aquaculture. Present review overlooks the available references and do objective thinking which is beneficial for the further researchers

Key Words - Sexual Dimorphism, Sex determination, Bivalve, Shell fish, Protandrous

I. INTRODUCTION

Bivalves are the one of the most important class of mollusc as they are highly nutrient and can survive in estuarine conditions. They are filter feeders and can act as cleaners in the aquatic ecosystem. They sustain with microorganisms and they require no extra feed for the farmers to grow. Willer and Aldridge (2020) reported bivalve as having remarkable potential to provide nutrient dense food to people along with sustainable environment. Reproductive patterns in bivalves (Ostreidae, Pectinidae, Veneridae and Arcidae etc..) show sexual dimorphism, i.e. protandrous hermaphrodites. Karapunar,et al., (2021).During first maturation all are males and sex reversal happens after two years which limits brood stock conditioning for aquaculture. (Breton etal., 2018). Morphological changes during reproductive stages were reported by (Ceuta LO et al., 2012). The sex-determining mechanisms in bivalves are still not fully understood, but it is known that both genetic and environmental factors play a role. In bivalves, sex determination can be influenced by various epigenetic and genetic factors .

2. Methodology

This paper is based on the review of literature based on sexual dimorphism and sex determination in bivalves. References were searched from peer reviewed journals and sorted for relevance and tabulated for better comprehension.

3.Result

This review paper provides comprehensive overview of the current state of knowledge of sex determination mechanism in bivalves. Literature relevant during search in peer-reviewed journals is summarised in a table form.(Table1)

Table1 : Sex determination mechanism studies in Bivalve

Sr. No.	Author	Bivalvia (Species)	Methods/ Techniques	Result
01	Teaniniuraitemoana,V et al., 2014	*Pinctada margaritifera*	Next-Generation Sequencing and RNAseq technology.	1. Presence of known specific genes coding for proteins involved in sex determinism and/or differentiation, such as dmrt and fem-1 like for males, or foxl2 and vitellogenin for females. 2. The specific gene expression profiles of pmarg-fem1-like, pmarg-dmrt and pmarg-foxl2 in different reproductive stages (undetermined, sexual inversion and regression) suggest that these three genes are potentially involved in the sperm-oocyte switch in *P. margaritifera*.
02	Flynn K. et al., 2013	*Elliptio complanata*	120 adult freshwater mussels, Elliptiocomplanata, were exposed to ATR at the environmentally relevant concentrations of 1.5, 15, or 150 µg/L.	1. Female controls burrowed overall approximately 30% less than males, 2. Atrazine at 15 µg/L feminized burrowing in both sexes, in that exposed animals burrowed 20% less than their same-sex controls. 3. Males treated with 1.5 µg /L ATR displayed approximately 20-fold higher vitellogenin (VTG) levels than same-sex controls. 4. Higher concentrations of ATR were not associated with increasing effects. 5. A scatterplot showed a weak binomial curve associating low burrowing with high VTG levels.
03	Ceuta LO et al., 2012	*Tagelus plebeius*	Morphological studies	1. The gonads of both males and females appeared milky white, without sexual dimorphism. 2. Microscopic analyses indicated a M:F ratio of 1.06:1 and continuous reproduction of T. plebeius in the region. 3. The period from August to October showed the most intense spawning.
04	Teske PR et al.,2012	*Perna perna*	mtDNA Analysis	1. Using mtDNA to identify sex-specific differences in genetic structure by contrasting it with biparentally-inherited markers is problematic as it also contain information about male line along with female. 2. sex-specific differences were found in a passively dispersing species in which sex-biased dispersal is unlikely highlights the fact that significant genetic

				structure is not necessarily a function of low dispersal potential or physical barriers. 3. Higher survival rates of males in non-native habitats can erase the genetic structure present in their mothers within a single generation.
05	Cubero-Leon E,etal., 2011	*Mytilus edulis*	In this study, two CYP3A-like mRNAs have been isolated from the mussel (Mytilused ulis), and their seasonal expression profile and modulation by estrogens examined.	1. Sexual dimorphism of CYP3A-like mRNA expression was not observed in mussel gonads of individuals collected throughout a year 2. natural variation in gonadal CYP3A-like mRNA expression was observed, with highest levels of CYP3A isoform1 and lowest levels of CYP3A isoform2 mRNA during the maturation and spawning season. 3. Exposure to a 10% sewage treatment works extract did not result in any significant changes in mRNA expression of CYP3A-like. 4. In contrast, exposure to E2 (200 ng/L) and TBT (100 ng/L) significantly down-regulated the expression of CYP3A-like isoform1 but not CYP3A-like isoform2 suggesting differential regulation.
06	Jonaldo R andG.BOHS, 2011	*Anomalocardi abrasiliana*	Morpholog ical and histologica l stuides	1. The water temperature at the site ranged from 24 to 30.5 ºC (mean: 27.4 ºC; SD ± 1.9), salinity from zero to 23 (mean: 13.7; SD ± 7.5) and rainfall from 28.3 mm to 248.8 mm monthly (yearly mean: 130 mm). The sample (n = 478) showed a sex ratio (M: F) of 1: 1.2 ($p < 0.05$) and no cases of hermaphroditism. 2. There was no sexual dimorphism. Males and females showed reproductive synchrony.
07	Reichenbach F ET AL., 2012	*Anodonta anatina*	Sexual dimorphis m in overall size, growth rate, sagittal shape and density of shells. In addition to sexual dimorphis ms, infestation by bucephalid trematode parasites	1. shells of females were significantly wider than males, probably as a result of altered shell growth to accommodate marsupial gills. 2. In two of these populations, female shells were additionally significantly thinner than those of males, which could be a result of resource depletion by offspring production. 3. Two other A. anatina populations showed no significant dimorphic patterns, and 4. Interpopulation difference in the degree of sexual dimorphism may reflect the

			(Rhipidocotyle sp.).	overarching effect of habitat on
09	Mikhailov AT ET AL., 2015	*Mytilus galloprovincialis*	At all periods of the annual cycle the proteins specific of male/female gonads were identified.	1. "male-associated polypeptide" with apparent MW 39 kDa (MAP-39), has been biochemically and immunochemically characterized.
10	Turner RD,1983	*Zachsia Sp*	Not mentioned	1. The occurrence of dwarf males in Zachsia appears to be the first case in the Teredinidae and the first outside the Leptonacea. 2. Female Zachsia release straight-hinge larvae that develop in the plankton and settle on living rhizomes of Phyllospadix. 3. Larvae entering mantle pouches of females become males.
11	Karapunar, B Et al., 2021	*Nicaniella rakoveci*	Morphological and Principal component Analysis	1. Protandrous females have more inflated valves than the males. The formation of crenulations was probably related to allocation of resources for reproduction. 2. The most likely function of the crenulations was to increase the internal shell volume in the female stage to accommodate more eggs rather than being an adaptation against predation as often assumed for other bivalves. 3. The formation of crenulations is part of the protandrous life history and probably is controlled by a genetic mechanism that is also responsible for sex change
12	Jillian R. et al., 2022	*Arctica islandica*	Morphological studies	1. Females begin to outgrow males between the ages of 5 and 15 y at sizes 50–55 mm, though this varies amongst the sites and both sexes diverge between decades. 2. This sexually dimorphic growth is not caused by protandry, nor is it compensation for a differential mortality rate between the sexes. 3. Egg sizes in *A. islandica* are larger than those of most other bivalves with planktotrophic larvae.
13	Feng et al., 2023	*Chlamys nobilis*,	Physical parameters like temperature on sex changes	1. High temperature can induce sex reversal in noble scallop *Chlamys nobilis*, and sex and age have significant effects on sex reversal rate 2. The egg diameter of sex reversal scallops was

			and egg diameter	significantly smaller than that of normal scallops, the offspring of sex reversed scallops grew faster than that of normal scallops

4.Discussion

Bivalve culture is rapidly expanding area of world aquaculture, accounting about 16 million tonnes of coastal and marine animal aquaculture in 2015 with an estimated market value of 17.1 billion $ (FAO 2016). Most of the bivalves are sedentary organism and are filter feeders. They are also important as they are having very important role in carbon sequestration in water body. According to the latest research by Insight Ace Analytic, the Global Bivalve Market is valued at US$ 20.85 Billion in 2022**,**and it is expected to reach US$ 27.94 Billion by 2031**,** (D'zoza, 2023). Reproduction during peak market season will reduce the meat amount in shell fish. Literature studies revealed the genes dmrt and fem-1 like for males, or foxl2 and vitellogenin for females by (Teaniniuraitemoana et al., 2014) also confirmed fluctuation of vitellogenin hormone (Flynn K. et al., 2013). As reported by Bull (1983) Differentiated sex chromosomes determine sex with male/female heterogamy or homogamy. Guo et al. (1998) suggested that a single major gene is responsible for sex determination in the Pacific oyster. The gene has two alleles: a dominant M allele for male maturation and a protandric F allele. In this model, FM oysters are fixed males, while FF oysters may mature as males or females depending on other genetic or environmental factors . The proportion of females in the Pacific oyster population increases with age, which is attributed to the fact that the proportion of FF oysters increases with age (Hedrick and Hedgecock, 2010). Genomic and proteomic studies at different seasons in the same group of bivalves will help to elucidate as temperature is giving a significant role in changing sex of the bivalves. As there is no concrete reason available for Sex determination mechanism in bivalves, more detailed research is needed to know effect of the genetic and environmental factors involved in sex determination and sex change of bivalves. Present review should improve our understanding of the underlying mechanisms in bivalves sex reversal and sex determining. Research on bivalve is very much useful in providing the high protein meat, that is nutritious food to human populations

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6.References

1. Breton, S., Capt, C., Guerra, D., Stewart, D. (2018). Sex-Determining Mechanisms in Bivalves. In: Leonard, J. (eds) Transitions Between Sexual Systems. Springer, Cham.
2. Ceuta LO, Boehs G. 2012. Reproductive cycle of Tagelus plebeius (Mollusca: Bivalvia) in the estuary of the Cachoeira River, Ilhéus, Bahia, Brazil. Braz J Biol. Aug;72(3):569-76.
3. Cubero-Leon E, Puinean AM, Labadie P, Ciocan C, Itoh N, Kishida M, Osada M, Minier C, Hill EM, Rotchell JM. 2012. Two CYP3A-like genes in the marine mussel Mytilus edulis: mRNA expression modulation following short-term exposure to endocrine disruptors. Mar Environ Res. Mar;74:32-9.
Daniel D'zouca, 2023. linkedin.com/pulse/bivalve-market-research-report-2023-insightace-analytic-d-souza
4. FAO (2016) The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Food and Agriculture Organization, Rome. 200 pp
5. Flynn K, Wedin MB, Bonventre JA, Dillon-White M, Hines J, Weeks BS, André C, Schreibman MP, Gagné F. 2013.Burrowing in the freshwater mussel Elliptio complanata is sexually dimorphic and feminized by low levels of atrazine. J Toxicol Environ Health A.76(20):1168-81.
6. Guo X, Hedgecock D, Hershberger WK , Cooper K, Allen SK . 1998. Genetic determinants of protandric sex in the Pacific oyster, *Crassostrea gigas* Thunberg , Evolution, (52) 394-402.
7. Hedrick, P. W. and Hedgecock, D. 2010. Sex Determination: Genetic Models for Oysters. Journal of Heredity, 101(5), 602-611
8. Jillian R. Sower, Eric Robillard, Eric N. Powell, Kathleen M. Hemeon, Roger Mann. 2022.Defining Patterns in Ocean Quahog (*Arctica islandica*) Sexual Dimorphism along the Mid-Atlantic Bight. Journal of Shellfish Research, 41(3), 335-348.
9. Joaldo Rocha Luz and Guiesia Bohs, 2011Reproductive cycle of Anomalocardia Brasiliana (Mollusca: Bivalvia: Veneridae) in the estuary of the Cachoeira River, Ilhéus, BahiaBrazilian Journal of Biology 71(3):679-86 DOI: 10.1590/S1519-69842011000400012
10. Karapunar, B.Werner, W. Fürsich, F. and Nützel, A. 2021. The earliest example of sexual dimorphism in bivalves—evidence from the astartid Nicaniella (Lower Jurassic, southern Germany). Journal of Paleontology, 95(6), 1216-1225. doi:10.1017/jpa.2021.48
11. Mikhailov AT, Torrado M, Méndez J. Sexual differentiation of reproductive tissue in bivalve molluscs: identification of male associated polypeptide in the mantle of Mytilus galloprovincialis Lmk. Int J Dev Biol. 1995 Jun;39(3):545-8.
12. Mingfei Feng , Karsoon Tan , Hongkuan Zhang, Huaiping Zheng. 2023.https://doi.org/10.1016/j.aquaculture.2022.739192

13. Reichenbach F, Baur H, Neubert E. 2012 Sexual dimorphism in shells of Cochlostoma septemspirale (Caenogastropoda, Cyclophoroidea, Diplommatinidae, Cochlostomatinae). Zookeys. 2012;(208):1-16. doi: 10.3897/zookeys.208.2869. Epub ul 17. PMID: 22859868; PMCID: PMC3406443.
14. Taro Yoshimura, Kotaro Shirai, Naoko Murakami-Sugihara, Saburo Sakai, Takenori Sasaki. 2019.Sexual dimorphism in shell growth of the oviparous boreal scallop *Swiftopecten swiftii* (Bivalvia: pectinidae), *Journal of Molluscan Studies*, Volume 85, Issue 2, May, Pages 253–261, https://doi.org/10.1093/mollus/eyz006
15. Teaniniuraitemoana V, Huvet A, Levy P, Klopp C, Lhuillier E, Gaertner-Mazouni N, Gueguen Y, Le Moullac G. 2014 Gonad transcriptome analysis of pearl oyster Pinctada margaritifera: identification of potential sex differentiation and sex determining genes. BMC Genomics. Jun 18;15:491. doi: 10.1186/1471-2164-15-491. PMID: 24942841; PMCID: PMC4082630.
16. Teske PR, Papadopoulos I, Barker NP, McQuaid CD. 2012 .Mitochondrial DNA paradox: sex-specific genetic structure in a marine mussel--despite maternal inheritance and passive dispersal. BMC Genet. Jun 13;13:45. doi: 10.1186/1471-2156-13-45. PMID: 22694765; PMCID: PMC3465189.
17. Turner RD and Yakovlev Y. 1983 Dwarf males in the teredinidae (bivalvia, pholadacea). Science. Mar 4;219(4588):1077-8. doi: 10.1126/science.219.4588.1077. PMID: 17811751.
18. Willer, D.F., Aldridge, D.C. 2020.Sustainable bivalve farming can deliver food security in the tropics. *Nat Food* **1**, 384–388. https://doi.org/10.1038/s43016-020-0116-8