SPERMATOGENESIS IN FISH UNDER THE INFLUENCE OF VARIOUS FACTORS WITH SPECIAL REFENCE TO INDIAN MAJOR CARPS

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Introduction:

Spermatogenesis is a dynamic process that follows a definite pattern in nature and ultimately produces haploid spermatozoa.The cellular basis of reproduction in males is the spermatozoon. They develop from testicular germinal epithelium [3] (spermatogonial stem cells), which first proliferate (spermatogonia), then differentiate into spermatocytes that undergo meiosis to become haploid spermatids that differentiate to become spermatozoa (spermiogenesis). The process as a whole is called spermatogenesis and requires a special environment. The gonadal function changes during annual reproductive cycles in male fish. During proliferation of diploid germ cells, the spermatogonia repopulate the testis lobules by mitotic cell division. Though spermatogenesis is a natural dynamic process, it has been modulated and manipulated by various factors to get maximum viable sperms for aquaculture practice. Environment and chemicals of natural and synthetic origin can interact with the endocrine system and alter the male germ cell generation and proliferation/inhibition in fish. In the present investigative review, an attempt has been made to ascertainvarious factors that influence the spermatogonial proliferation and maturation of fish with a special reference to Indian major carps (*Catla catla, Labeo rohita, Cirrhinus mrigala and Labeo calbasu).*

Methods:

Various maturity stages of fish (Indian major carps) were sampled to estimate their testis somatic index (TSI) at different times of the year. The immature fish were subjected to several external factors (environment) and some chemical inducers such as hormones and other inducing agents to estimate the semen quantity and quality and assess the spermatogonial proliferation due to these and also the regulation of spermatogenesis annually. A comparative evaluation of spermatogenic cycles with other species has also been done.

Results and Discussion:

Fish species inhabiting diverse ecological niche offers an enormous challenge to generalize their reproductive characters that includes theirsexual dimorphism, spermatogenic cycle (*in vivo and in vitro*), spermatozoon structure and the external inducers that modulate the spermatogenesis in fish with particular reference to Indian major carps (IMCs).The testes in

Table 1. A comparative account of gonadal (spermatogenic cycle) in different fishes

Species	Spermatogenesis	Inducement	Reference
Catfish, *H. fossilis*	Annual gonadal cycle	Natural cycle	[9]
Rainbow trout, *S. gairdneri*	Twice in year (Autumn and summer)	Natural cycle	[1]
Rainbow trout, *S. gairdneri*	Advanced maturation and spawning by 6-12 weeks at 9°C	Photo period manipulation	[12]
Tilapia	Testicular activity restricted to autumn and winter, and testes are in resting phase from July-September in equatorial zone	Natural photoperiod	[4]
Indian major carps	Increasing gonadal recrudescence; males attain maturity earlier than females	Photo period manipulation	[10]
Indian major carps	Advancement of sexual maturation and off-season spawning of IMCs	Photothermal manipulation	[7]
Zebra fish *Danio rerio*	Combined duration of meiotic and spermiogenic phases is very short in this species and lasts approximately 6 days	Natural cycle	[5]
C. fasciata	Spermatogenicphase 6 days	Natural cycle	[8]
Black molly, *P. sphenops*	Spermatogenic phase 21days	Natural cycle	[2]
IMCs & L.calbasu	Spermatogenic phase 15-21 days	GnRH based inducement	Present study

most teleost reported including that of the IMCs are bilobed, with spermatogonia dispersed throughout the gametogenic epithelium of the seminiferous tubules.The sexual dimorphism is clear in species during the reproductive season (perennial spawners in nature) however, some are very inconspicuous during non-spawning season (IMCs) [11, 6]. The spermatogenic cycle varies among the fish species (Table 1) and also the sperm density (40 to 53,000 millions/ml). With the advancements in reproductive biology of fishes, it is now possible that spermatogenesis can be modulated and manipulated by various factors to get maximum viable sperms for aquaculture practice.

References:

[1]BILLARD, R., BRETON,B. 1978. Rhythms of reproduction in teleost fish. In Rhythmic activity of fishes, edited by J.E. Thorpe. London, Academic Press, pp. 31-53.

[2]FELICE, DE DA., RASH E. M. 1969. Chronology of spermatogenesis and spermiogenesis in poeciliid fishes. J. Exp. Zool., 171:191–208.

[3]GRIER, H. J., TAYLOR, R. G. 1998. Testicular maturation and regression in the common snook. J. Fish Biol., 53:512-542.

[4]HYDER, M., 1970 Gonadal and reproductive patterns in *Tilapia leucosticta* (Teleostei: Cichlidae) in an equatorial lake. Lake Naivasha, Kenya. J. Zool., 162:179-95

[5]MARCELO, C., LEAL, EDSON R., CARDOSO, RAFAEL H. NO´BREGA., SERGIO, R., BATLOUNI, JAN BOGERD., LUIZ R. FRANC., SCHULZ,RU¨DIGER, W. 2009. Histological and Stereological Evaluation of Zebrafish (*Danio rerio*) spermatogenesis with an emphasis on spermatogonial generations. Biol. Reprod., 81: 177–187

[6]ROUTRAY, P., VERMA, D. K., SARKAR, S. K., SARANGI, N. 2009. Recent advances in carp seed production and milt cryopreservation. Fish Physiol. Biochem., 33: 413-427.

[7]SARKAR, S. K.,SAHA, A.,DASGUPTA, S., NANDI, S.,VERMA, D. K.,ROUTRAY, P., DEVARAJ, C.,MOHANTY, J.,SARANGI, N., EKNATH, A. E., AYYAPPAN, S. 2010.Photothermal manipulation of reproduction in Indian major carp: a step forward for off-season breeding and seed production. Curr. Sci., 99: 960-964.

[8]SINHA, G. M., MONDAL, S.K., MIDYA,T., GHOSAL, S.K. 1979. Chronology of meiosis and spermiogenesis in a fresh-water teleost fish, *Colisa fasciata* (Bloch and Schneider). Z. Mikrosk.- Anat. Forsch., 9z3:442–448.

[9]SUNDARARAJ, B.I., VASAL, S. 1976. Photoperiod and temperature control in the regulation of reproduction in the female catfish, *Heteropneustes fossilis*. J. Fish Res. Board Can., 33: 959-73.

[10]VERGHESE, P. 1975. Internal rhythm of sexual cycle in a carp *Cirrhinusreba* (Ham.) under artificial conditions of darkness. J. Inland Fish. Soc. India, 7: 182-8.

[11]VERMA, D. K., ROUTRAY, P., NANDA, P.K., SARANGI, N. 2009.Seasonal variation in semen characteristics and biochemical composition of seminal plasma of mrigal, *Cirrhinus mrigala* (Ham.).Asian Fisher. Sci., 22: 429-443.

[12]WHITEHEAD, C., BROMAGE, N. R., FORSTER, J. R. M., MATTY, A. J. 1978.The effects of alterations in photoperiod on ovarian developmental and spawning time in the rainbow trout (*Salmo gairdneri*). Ann. Biol. Anim. Biochim. Biophys., 18:1035-43.