Fish constitutes the most diversified vertebrate group, adapted to a wide range of aquatic environs (Nelson, 2006). India harbors a rich fish diversity having over 2319 fin fish species, which includes 838 fresh water, 113 brackish water and 1368 marine fish species (Kapoor et al., 2002; Lakra et al., 2009). This vast diversified class of fishes has evolved varied reproductive strategies which are finely ingrained in gonadal morphology, gametogenesis and temporal synchronization vis-à-vis seasonal changes ensuring maximum survival of the progeny (Parenti and Greir, 2004; Belova, 2008).

Reproduction is a multistep selective finely tuned process by which species perpetuate. The successful establishment of any fish species in any specified habitat is ultimately determined its ability to reproduce successfully to maintain a sizeable population in ever changing environment (Moyle and Czech, 2000). The reproductive behavior in fishes reveals a remarkable diversity. Timing and peak activities of reproduction and growth in many species have demonstrated that the reproductive cycle of fishes is closely synchronized with the seasonal changes. Reproductive parameters such as the size of fish at first maturity, spawning frequency, fecundity, sex ratio, etc. are of great value in the formulation of management of catch and culture fisheries (Bal and Rao, 1984).

Information on the important parameters of fish reproduction are of extreme importance in improving performance of the limited number of fish breeding centers/seed farms, low fish seed supply of commercially explored and unexplored fish species. The maintenance of continuous fish seed supply to fulfill the gap between demand and supply in numerous fin fish species is still awaited. Sufficient data on various events of reproduction and development can only provide suitable answers to these questions. The successful adoption of induced breeding technique, using pituitary hormone, for a number of important species has played an important role in improving the fish seed supply in some selected fish species.

The rainbow trout, *Oncorhynchus mykiss* (Walbaum, 1792) is a salmoniform fish and is known to spawn only once per year in natural conditions (Scott, 1987; Tyler et al., 1990). Salmonids include most economically valuable fishes which include Pacific and Atlantic salmon, trout, charrs, and whitefish (Tyler, 1991; Tyler and Sumpter, 1996).
The rainbow trout is native to eastern Pacific Ocean coastal watersheds and extends from Baja California in the south up to Kamchatka Peninsula and Alaska in the north (Thorgaard, 1983; Stewart and Watkinson, 2004). Thereafter it has been cultured in northeastern North America since 1874, with the establishment of the Caledonia Hatchery in New York State (MacCrimmon and Gots, 1972). Today, rainbow trout are cultured globally due to its introduction in every continent except for Antarctica (MacCrimmon, 1971; Casal, 2006). In India trout is the exotic fish species and was introduced by Mitchell in 1900 from Scotland in Kashmir valley. The trout species are now reared throughout in Kashmir. Since 1900 brown trout and rainbow trout has established well throughout the Jammu and Kashmir. Till date, there is no literature available related to fish reproduction from Kashmir waters, there is only small fragmentary information available on breeding biology including biochemistry among the trout strains of different countries. Therefore, it becomes utmost important to analyse these fish species in terms of breeding biology which will help to devise strategies for conservation of these exotic fishes ensuring their survival in India.

A number of biologists have studied the reproductive biology of some important teleosts from Indian waters viz. (Radhakrishnan, 1957; Qasim and Qayyum, 1963; Khan, 1972; Gowda et al., 1988; Doddamani et al., 2002).

Determination of the age and size at the attainment of sexual maturity is of fundamental importance in commercial exploitation of any fish species. These important parameters determine the population dynamics which are commonly estimated for species of economic importance (Hunter et al., 1992).

Determination of development of sexual maturity and reproductive cycle in female teleosts is an important phenomenon, the seasonal developmental changes in fish gonads are an important method to determine the reproductive cycle (Sivakumaran, 1991). Wallace (1985); Celius and Walther (1998) have studied that in female fish, the ovarian growth is due to the incorporation of vitellogenin protein and zona radiata proteins. These proteins are directly under the control of sexual hormones. During ovarian growth, these proteins are initially synthesized by liver under the stimulation of an important female specific hormone which is known as “estradiol” and later are transported in the bloodstream to the follicular layer from where the proteins are endocytosed by oocytes and incorporated for the formation of both yolk and vitelline envelope. In male teleosts, a number of researchers have studied testicular development among the notable biologist who have contributed in fish reproduction are Turner (1919) in Perch, Van Oordt (1925) in Xiphophorus helleri, Craig-Bennet (1931) in Gasterosteus aculeatus and Nair (1965) in Silurids. Fishes exhibit remarkable diverse
reproductive strategies, but despite this the basic organization of the testis in fish is notably conserved. In a number of male fish species, the histological and ultrastructural analysis of the testis revealed six different types of germ cells viz., primary spermatogonia, secondary spermatogonia, primary spermatocytes, secondary spermatocytes, spermatids and spermatozoa.

Lipids in fishes are the main source of energy for reproduction, during reproduction in female fish a large amount of lipids are required for the maturation and production of eggs (Goda et al., 2007; Ebrahimnezhadarabi et al., 2011). Lipids are reported to fluctuate with each developing stage of fish. The change in lipid content and its classes in gonads is directly correlated with maturity and spawning of fishes (Mourente and Odrizola, 1990). The fluctuation in lipid occurs mainly in ovary, testis and liver, which results into the variations in gonadosomatic (GSI) and hepatosomatic indices (HSI) (Love, 1980). Higher investment of energy is required during the reproduction, and therefore the lipid reservoir in liver and muscles are mobilized and transferred to the gonad during the maturation and spawning of the fish (Zaboukas et al., 2006; Sutharshiny and Sivashanthini, 2011; Singh et al., 2012).

Lipids are a complex class of compounds and are divided into two groups, one is polar lipids which are composed of phospholipids and the second one is non-polar lipids which constitutes triacylglycerols and cholesterol (Tocher, 2003). Phospholipid constitutes the main lipid of cellular membranes and this is reported to be the important constituent of egg yolk in fish (Johnson, 2009). Triacylglycerol has been reported to be the major energy storage form in the fish and is stored in liver and muscle (Shulman, 1974; Sheridan, 1994). While cholesterol acts as a precursor for the steroid hormones and also performs various important cellular functions in the testis (Scott, 1987; Sharpe et al., 2006).

Fish is known as a rich source of proteins. The proteins are important components of living matter and also constituents of the protoplasm which form the basis of life (Jain and Singh, 1981). Fish contains all essential amino acids in appropriate proportion and therefore has a high nutritional value. Biochemical studies related to proteins and lipids has drawn a special attention because these are the major sources of energy (Joshi et al., 1979). The protein content is reported to vary with species to species and within the same species. It is also known to fluctuate with the development of gonads throughout the breeding cycle (Stansby, 1962). Shreni (1980) has reported that the protein content in fishes fluctuates with maturity of fishes. During the mature stage of fish, both ovary as well as testis increase many fold in size which results in an increase in the protein content during this stage.
Specific biochemical changes also occur during the development and growth of the fish gonads. These metabolic activities are controlled by different enzymes. Acid phosphatase is a widely distributed enzyme it releases inorganic phosphate, which is regarded a key metabolite for cellular development (Biswas and Cundiff, 1991). Alkaline phosphatase being an intrinsic plasma membrane enzyme and is reported to be present in almost all animal cells (Mazorra et al., 2002). Ram and Sathayanesan (1985) have reported that acid phosphatases and alkaline phosphatase play a role in metabolic processes which include growth and cell differentiation, protein synthesis, absorption and nutrient transportation, and gonadal maturation. Alkaline phosphatase liberates inorganic phosphate (Pi) to the tissue which is required in the synthesis metabolites during different developmental stages of gonads. Change in phosphatase activity has been reported to impact on fish metabolism. It has been reported that during growth, illness and spawning of fish, activity of phosphatase fluctuates (Goldemberg et al., 1987; Matusiewicz and Dabrowski, 1996).

In teleost, reproduction is coordinated and controlled by different sex steroid hormones. Hormones such as testosterone, 11-ketotestosterone, 17β-estradiol and progesterone are involved in the process of reproduction (Kime, 1993; Barannikova et al., 2002, 2004). The control and coordination of reproduction (maturation of gonads) in fish is through the brain-pituitary-gonadal axis. Several important factors like photoperiod, water temperature, feeding and rainfall stimulate the brain to release gonadotropin releasing hormone (Rottman et al., 1991; Zohar et al., 2010). Testosterone (T) and 11-ketotestosterone (11KT) are the two important hormones which play an important role in male fish reproduction including maturation of the gonads, and it has also been reported that in salmonids progesterone is involved in spermiation (Nagahama, 1987).

Steroid hormones have been reported to play a direct role in the ovarian development of fish. While maximum level of 17-estradiol (E2) is reported to be present during vitellogenesis stage, progesterone is found to be maximum during ovulation or spawning stage. The relationship between changes in plasma levels of steroids and development of oocyte has been demonstrated by a number of researchers in a number of different teleosts viz. Salmon fish (Whitehead et al., 1983; Truscott et al., 1986), Heteropneustes fossilis (Lamba et al., 1983), Hiodon alosoides (Pankhurst et al., 1986), Sitzostedion vitrum (Malison et al., 1994), Sillago japonica (Matsuyama et al., 1990), and Centropomus undecimalis (Roberts et al., 1999).
Aim of the Work

Considering the great diversity of fish fauna, the data on gonad histology, ultrastructure and biochemical is scarce and is restricted to few species only. Fragmentary information is available regarding histology, ultrastructure and biochemical analysis for rainbow trout gonads. Therefore, the purpose of the present study was to systematically analyze the phenomenon of oogenesis, spermatogenesis and their biochemical alterations in the rainbow trout gonads, a single spawning fish from the Kashmir waters.

The objectives of this study are as:

1) Morphometric, gravimetric and histoarchitectural changes in gonads during different phases of circannual cycle.
2) Ultrastructural variations in follicles at different stages of growth and atresia in trout ovaries.
3) Fine morphology of somatic and germ cells during spermatogenesis in trout testis.
4) Biochemical changes in protein profile, lipids (cholesterol, phospholipids, triglycerides, glycolipids and free fatty acids) and in some enzymes of gonads.
5) Hormonal changes (estrogen, progesterone, and testosterone) in gonads of trout.