



Effect Of Testosterone Propionate And Thyroxine On Thyroid Gland Of *Clarias Batrachus*

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Abstract: Thyroid hormones, including thyroxine (T₄) and triiodothyronine (T₃), play a crucial role in regulating growth, metabolism, and reproduction in fish. Studies also indicate that thyroid hormones can affect gonadal steroid syntheses and sexual maturation in fish. This study enhances our understanding of the multi hormonal control of teleost metabolism and provides a baseline for molecular investigations. The present experiment was done during the off period of their breeding season. Testosterone is an anabolic steroid, and research on its impact on thyroid function, especially in fish, is pretty-specific generally, steroids can influence thyroid function, but outcomes vary based on species, dosage, and duration. Testosterone and thyroxine have significant effects on the thyroid gland of *Clarias batarachus*.

Keywords: - *Clarias Batarachus*, Testosterone Propionate, Thyroxine, Thyroid Hormones, and Metabolism.

Introduction: -

Clarias batrachus is an air breathing, fresh water fish, with its peculiar habitat. Spanning etc. It is a commercially important fish found almost throughout the aquatic system of Bihar.

The bionomics and life history of present air breathing fish and other fishes were studied earlier by eminent worker like KOJIMA (1981), HOAR et. al. (1983) SHRIVASTAVA (1984), DALWELL (1985) and perhaps many other. However there was apparently a paucity regarding the present works.

MATERIALS AND METHODS:-

The fishes were collected from different places of nearby fresh water reservoir with the help of fisherman and brought to the laboratory which was kept in a large aquarium, at least for 15 days, for acclimatization. The fishes were daily fed with small fishes, goat liver, earthworm and gut of fishes etc. The water of the aquarium containing fishes was changed daily. After complete acclimatization the fishes were divided into 4 groups in 4 different aquaria. Care was taken for good health and water condition of each aquarium daily.

At least 8 fishes were kept in each aquarium. Number 1 aquarium being normal fish group. After standardizing fishes of second aquarium were injected with 0.01 mg per gram body weight of testosterone propionate (TP) and thyroxin daily continuously for 5 days.

The fishes of 3rd aquarium were treated with the same way for ten days. Likewise the fishes of the 4th group were also feted and kept in aquarium for 15 days. In the meantime the health and mortality rate of each fish were minutely noted. The activity and morphological change were also observed, 2 fishes from the aquarium number 2 fishes from aquarium number 2, and fishes from aquarium number 3 and 3 fishes from aquarium number 4 were found dead. It was also observed that there activity of fishes also showed a decreasing tendency and in spite of proper and health care for their nutrition and water condition the effect of the drug supplied to the fishes had some sort of effect on the fishes. However after the regulation of temperature of water was enhanced with the help of thermostat the majority of fishes were found to be slightly, active.

The present experiment was done during the off period of their breeding season i.e. Nov. Dec. and Jan. The experimental fishes were sacrificed on the mid of each months.

To observe the thyroid follicles the complete tissue was collected located along the area of phalangeal mass most nearer to the arterial system and its bronchial branches.

The tissues were fixed in begins fixative and after processing the serial section were cut at 6 and stained with hoemotoxilin and eosin, mounted and observed under research microscope which were then compared with the normal group of fishes. The follicles were found encapsulated and were dispersed in groups along the tissue of pharyngeal mass.

Table No-1

Data temperature, humidity rainfall and day length during Nov. 2025, Dec. 2025, Jan. 2026.

Date	Max Temp (°C)	Min Temp (°C)	Humidity (%)	Rainfall (mm)	Day Length
14 Nov 2025	28°C	15°C	59%	0.0 mm	11h 00m
15 Nov 2025	27°C	15°C	61%	0.0 mm	10h 59m
16 Nov 2025	27°C	16°C	60%	0.0 mm	10h 58m
14 Dec 2025	24°C	11°C	54%	0.0 mm	10h 35m
15 Dec 2025	24°C	10°C	55%	0.0 mm	10h 34m
16 Dec 2025	23°C	10°C	58%	0.0 mm	10h 34m
14 Jan 2026	26°C	11°C	30%	0.0 mm	10h 43m
15 Jan 2026	27°C	11°C	30%	0.0 mm	10h 44m
16 Jan 2026	26°C	11°C	33%	0.0 mm	10h 45m

Table No.-2

Average temperature (0c), average rainfall (in mm) average humidity (%) and length of Bhagalpur in the months of Nov. & Dec. 2025 & Jan. 2026

Month	Avg Temp (°C)	Avg Rainfall (mm)	Avg Humidity (%)	Avg Day Length
Nov 2025	22.3°C	6.8 mm	71.60%	11.0 hours
Dec 2025	17.0°C	6.0 mm	71.20%	10.6 hours
Jan 2026	13.9°C	11.2 mm	78.80%	10.7 hours

Table No.-3

Average body weight (gm) \pm relative weight of testis, epithelial cell height of thyroid in *Clarias batrachus*

Months	Body Weight (gm) $\pm ve$	Relative Weight of testis	Epithelial cell height of thyroid in use ($\pm ve$)
Nov. 2025	270 \pm 1.8	0.102 \pm 0.002	4.49 \pm 0.83
Dec. 2025	261 \pm 1.37	0.063 \pm 0.003	3.79 \pm 0.31
Jan. 2026	256 \pm 1.36	0.061 \pm 0.001	3.74 \pm 0.79

Discussion: -

The thyroid gland in fishes has been studied by a numbers of workers and according to GORBMAN and BEARN (1964), the teleostian thyroid are mostly fused and are generally found around the ventral aorta and its afferent bronchial arteries. But cases are there in which thyroid have been found around ventral aort. SATHYANE SAN and SHRIWASTAVA (1970) in *Mystus vittatus*, SHRIWASTAVA and SATHYANESAN in *channa punctatus*, *Hebtropnuslus fossils* and *clarias batrachues* PANDEY (1975) in *Heteropnustus fossils* and TOWHED (1982) in *Monepterus Chuchia* have located the thyroid follicle in the pharyngeal mass and around the afferent bronchial arteries. Some workers have reported thyroid follicle (SATHYANESAN, 1964 in flat fish, AHMED, 1968 in *Mystus vittutus* and TOWHEED. (1982) in *Moneptrus chuchia*

They have also found the seasonal variation and cyclic activities of the thyroid gland in fishes depending upon the variation in comparison to environmental condition.

Histometric changes in the thyroid follicle have been used widely criteria for their activities in fishes by several workers. SWIFT and PICKFORD, (1965); VERNIDUB and KOLOVABA, (1971) TIWARI, (1979); OLIVERAN, (1955) has observed that thyroid follicles with high epithelial cell height more of 1 then those with low epithelial cell height. This further supported by SINGH (1968) in two fishes.

SWIFT (1959) has studied the annual cyclic activities of thyroid in immature brown trout and has observed two peaks of activities one i spring having marked increased in epithelial cell height and the other in mid-summer with less but significant increase in epithelial cell height in *Mystus vittatus* and *Esomus danricus*. Ist in May, June & 2nd in September.

The follicles of the thyroid gland of the present fish was also have been found in the phalangeal region below and slightly lateral to ventral aorta which is continued in small groups starting from the 1st afferent bronchial artery up to the 4th bronchial artery.

Scattered thyroid follicle was also seen in the head kidney as well as other part of kidney proper.

Since there was a limitation of time so we could not observe the yearly data of each parameter in a regular manner what we have done is the data observed during the period November to January 2025-2026 which was period of full winter (Table 1). Unluckily this period was the off period. So for as the breeding cycle is concerned the follicular structure in the plate shown flat cells height surrounding dense colloid without any sign of vascularization.

The table 3 shows some of the important meteorological data which can be easily compared with the data of epithelial cell height of the thyroid follicle during the month November to January.

In the present fish as the reports are available the peak of the thyroid follicle having very prominent cuboidal epithelium of the follicle were found during the months June-July i.e., during the summer period meaning thereby during their height of breeding period.

Like the thyroid the seasonal variation were observed in adrenocortical tissue as marked by the variations of mean nuclear diameter (table 4) which was found to be minimum during the month of Decembers which conceded with the minimum weight of the gonads. The observation have been confirmed depending upon the data available by a number of distinguished authors who also reported a sharp decrease reaching minimum in the month of December. Likewise the minimum cortical volume of adrenocortical tissue was in December coinciding with the observed data of epithelial cell height and fractional adrenocortical tissue. In the present fish however fractional volume of chromofin cell have got an inverse relationship with the cortical tissue

From the above observation it appears that the adrenocortical activities of *Clarias batrachus* coincided with the activities of thyroid and also with natural photoperiod and temp.. Thus it might be possible that the cyclic activities of the thyroid and adrenocortical tissue in different months of the year might be running almost parallel to each other.

As said before the cytological and histological criteria for assessing the functional activity of the thyroid (epithelial cell) height visualization of colloid/have been favored by several authors. In cyclostomes & teleost the organized thyroid gland is generally lacking instead the follicle are scattered in singly or in small groups in the loose connective tissue in the regions of pharynx from the 1st to the 4th aortic arches GORBMAN and BERN (1964) compact and encapsulated thyroid in fishes has also being reported in sarda. In *Channa punctuata* and *Heteropneustus fossils* SHRIWASTAVA (1971) in *Latimaria* CHALUMNAE SHARNING (1972). In *Heteropneustus fossils* (PANDEY, 1975) where as in many other air breathing fishes diffused thyroid follicles have been reported by Singh et al (1974) in *Heteropneustas foudas*

Khanna (1970) has stated that thyroid of *clarias batrachus* is of intermediate type in between compact and scattered ones.

In the present study of the air breathing fish, *clarias batrachus*. The thyroid follicle is found to been capsulated & follicles are scattered in groups and usually follow the roots of the branches into the gills. Perhaps the most unusual anatomic characters of some of the teleost thyroid is tendency to undergo wide spread dispersion out of pharyngeal area, the most common non pharyngeal site of the thyroid follicles is being found in the head kidney (Baker-Cohen 1959 a).

In the kidney of *Platy fish*, (*Platy pocilus* sp.). This type of displaced thyroid follicles is known as heterotrophic thyroid which may be dispersed along the other organ also.

Several finding of the seasonal activity of the thyroid of different species of fishes indicate that the thyroid has either one or two peaks of activity. So for as the present fish is concerned it has observed that only one peak prevails as reported by several authors. fishes diffused thyroid follicles have been reported by Singh et al (1974) in *Heteropneustas foudas*

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THYROID IN RELATION TO FEW ENVIRONMENTAL FACTORS.

In the present work, we have considered the water temperature, humidity, rainfall, and day length as climatic factors.

In spite of the difficulties of not having the data of complete year due to the lack of time depending upon the previous literature and present part observation, we may be able to conclude some remarks on the basis of our works.

Olivares (1955) & Welsol and Platin (1956) in *Mughiloratus Tinka tinka* and *Ciprinus Caprio* have found that the thyroid activity in these three species are not at all affected by temperature variations. Pandey et al (1975) in *Heteroneustus fossils*, Tiwari (1977) in *clarias batrachus* Tiwari (1979) in *Channa gachua* and Fassiruddin (1980) in *Anabas testudineus* have reported an increase in thyroidal epithelium with the increase in water temperature. Bota swift and GORBMAN separately in 1959 have reported a decrease in activity of thyroid with the decrease in temperature.

Hence, we see that there are a number of different findings prevails, that has been put forwarded by various authors in different ways. In the present investigations the thyroid activity apex be affected favorably with the increase and decrease of water temperature and is like the domestications of Barrington and Maly, Gorbman and Beth, Pandey, Tiwary, Fassiruddin etc.

Table No.-4

Average body weight, mean nuclear diameter PCV (packed cell volume) blood nuclear and other spaces in different month of Nov. 2025, Dec. 2025 Jan 2026.

Month	Average weight	Mean nuclear diameter	Packed cell volume		Blood vascular area
			Internal	Chromaffin	
Nov. 2025	275±1.15	4.19±0.18	93.19±1.37	3.07±0.31	3.74±0.27
Dec. 2025	266±1.49	4.07±0.15	92.67±1.12	3.24±0.22	4.09±0.15
Jan. 2026	264±1.36	4.15±0.14	91.87±1.74	3.85±0.07	4.28±0.19

THYROID IN RELATION TO PHOTOPERIOD

A number of workers have also reported the role of photoperiod in the regulation of thyroidal activity of fishes but the results are conflicting. A constant light without the increase in temperature could not affect the thyroidal follicles of *Ameiurus nebulosus*. (Berser & Blank, 1949) in winter. According to Rawat (1965) in *Pentus ticto* a complete darkness reduced the thyroidal activity. Swift, 1960 have reported that the cycle of thyroidal activity is under the influence of both the water temperature and photoperiod of which the water temperature is the main regulatory factor. Eales (1965) has reported in Juvenile *Salmo guidewire* that both rise in temperature and enhanced photoperiod have stimulatory effect on thyroid activity and the increase in thyroid follicular cell height depends much upon enhanced photoperiod. Pandey et al (1975) that increased epithelial cell height was associated with increase in day length.

In the present investigations of *clarias batrachus* a correlation between the day length and the activity of thyroid was marked like the report of Swift 1960 and Singh (1968). However temperature alone cannot be discarded strictly because both temperature and photoperiod is interlinked and temperature has got more effective factors.

HUMIDITY AND RAINFALL

So far as both the above parameters are concerned, a number of authors are linked with the endocrine and other physiological activities. In the present case when the experiment has been done. there is least or no rainfall and humidity so it cannot be said very clearly that whether their effects are having so much of value or not, if it would have been observed along with the data of whole year.

TESTIES

Clarias batrachus is sexually separate but there is no sign of sexual dimorphism. However during breeding season, minute study of these fishes, almost the same size indicates somewhat swollen abdomen of female in contrast to those of the males. In the earlier part of this project work, we have discussed about the observation of the testis as a cylindrical thick elongated structure separated men's for some distance in the abdominal cavity and attached with the cloaca posteriorly the anterior part of the testis is slightly broader in comparison to the narrower posterior part.

Lehri (1967) in *Clarias batrachus* have also reported posteriorly fused testis while Khanna and Pant (1966) have reported in *cliphthorex* the fusion of testis along their whole length. Raizada 1975 in *Nandus nandus* and Tiwari 1977 have reported a posteriorly fused testis. In the present investigation the distal end of each of the testis were found to be free and projected into the body cavity and as finger like caeca.

In the present investigation both the testis was almost equal in size. During the present investigation in the fish, the 2/3rd of the testis are responsible for sperm production and the rest 1/3 are glandular and a short transitional zone lies in between the two as described by Nair (1965).

A number of workers have reported seasonal changes in the gonosomatic index or relative wt. of testis of the number of fishes. On the basis of following formula relative weight of testis can be calculated

Relative wt. of testis = $\frac{\text{wt. of testis}}{\text{wt. of fishes}} \times 100$ gram

Table No.-5

Average data of no. of fishes, wt. of fish, relative weight of testis & epithelial cell height of normal fishes during the month of Nov., Dec. 2025, Jan. 2026.

Condition of fisher	No. of fish	Wt. of fish in mg	Rel. wt. of testis %	Epithelial cell height mm
Saline injection normal	4	214±1.77	0.080±0.009	4.47±0.79
Normal	4	215.25±1.33	0.105±0.012	4.98±0.35
Normal	4	216.75±1.96	0.096±0.001	5.31±0.46

Tiwari (1977) in *Clarias batrachus* has also reported a seasonal variation in gonosomatic index during different months of the year, which shows variations.

In the present investigation there has been slight variations have been observed which can be correlated with the water temperature.

Table No.-6

Effect of administration of testosterone propionate (TP) L Thyroxin (T4) and both TP and T4 average body wt. of fish. Relative weight of testis on different condition from period Nov. 2025 - Jan. 2026.

Condition of fish	No. of fish	Wt. of fish in mg	Rel. wt. of testis %	Mean nuclear diameter	Epithelial cell height mm
Normal T4+saline	4	214.75±0.15	0.2	4.98±0.79	0.66
Normal T4+TP	4	219.25±1.62	0.176±0.003	4.47±0.03	5.64±0.97
Normal +TP	4	216.50±1.71	0.175±0.002	4.54±0.29	6.87±0.57

THYROID IN RELATION TO ADRENAL.

Thyroid Adrenal relationship has also been reported by several workers, but it has been found to run parallel to the testicular cycle Ball (1960) in *Parcilia latipinna* has reported that during breeding phase when thyroid activity was at its peak, there was an increased inter renal tissue. In heteropneustus fossils, Pandey (1975) has observed parallel cycle of activity of inter renal tissues and thyroid gland. Tiwari (1977) in *Clarias batrachus* and Tiwari (1979) in *Channa gachua* have also reported in parallel cycle of activity of inter renal tissue and the thyroid gland.

The present Case of *Clarias batrachus* as in other fishes also showed a marked decrease during the off breeding during period of December. However a noticeable increase was observed after the injection of testosterone propionate and thyroxin.

As said before the activities of adrenocortical tissues were measured with the help of the process micrometry of their nuclear diameter. The data were calculated statistically in the lab.

The experimental: -

Most of the physiological functions in the body depend upon the constant level of hormones in the blood. The concentration of hormone itself became the homeostatically controlled factor of internal milieu. This is true for the hormones in particularly secreted by the thyroid, gonad and adrenal cortex. The warm blooded animals, the metabolic rate increases with the increasing concentrations of thyroid hormone & decreases with it decreasing concentration. In vertebrate generally cell of the function normally only when adreno cortical hormones are present in the blood in proper amounts. The adrenocortical hormones are therefore,

said to be exert a permissive action. Finally the sexually mature state of the vertebrate organism required the permanent presence of gonadal hormones in the blood (Jorgensen, 1977).

Thus it seems that the endocrine gland control by the biochemical & physiological processes of development growth, metabolism and reproduction in fishes (Zanuy & Carrillo 1977). The timing of reproduction the regulation of associated morphological changes, mobilization of the energy reserved for gonadal development & the intricate breeding behavior largely dependent on the internal secretion of the gland (Zanuy & Carrillo 1977).

To establish any relationship between the endocrine gland & biochemical & physiological activities experimental evidences is needed to be done. However various hormones have doubtful roles in the physiological ecological adaptation of fishes. As reported by a no. of author the steroids play a very important role in the physiology of fishes but effects of androgen are variable in different fishes. Regarding this a no. of scientist has tested experimentally the effects of a few related drugs to see any short of physiological changes in their activities.

The fishes possess even develop endocrine system comparable with that of other vertebrates animals. Resquine & Rosen Blown (1957) have found convincing evidence that chemical regulation in that fishes and the interrelationship of endocrine of target organ follow the general pattern recognized mammals. So hormones have been reported to play important role in physiological adaptation of fishes (whole 1959)

In the present investigation it has been observed that the fishes become very active after the injection of L. thyroxin which may be because of the stimulation to high metabolic rate. The color of the skin was marked to change with which was found to be higher in the thyroxin & testosterone propionate injected fishes and slightly darker in.

In the present study of *Clarias batrachus* in parallel decrease in the relative weight in the activity of testis and the activity of thyroid was marked in all the experimental conditions. Thus it appears that the testis & the thyroid show a parallel cycle of the activities & are interrelated with each other & may be interdependent at the biochemical level.

Due to lack of so much of time we could not correlate the experimental part of the glands with other important target organs under the direct or indirect control of the above drugs used. The blood parameters are thought to be the carrier of these hormones so in that sense they become very important part of conduction of the different physiological activities occurring with injection of the above parameters.

From the present investigation of *Clarias batrachus*, it appears that thyroid, gonad & adreno cortical tissue play a vital role in maintaining and regulating the physiology of the fish, but whether they act independently or under the influence of under internal or external are not fully & clearly understood & it requires further experimental evidences, as also have been reported by a no. of scientist.

Environmental conditions are variable unsuccessful leaving of animal demand a continual adjustment of regulation of internal media in relation to their environmental changes (Hoary 1959).

Chaurasia et al. (1996): Studied lead-induced thyroid dysfunction in *Clarias batrachus* and found changes in T3 and T4 levels.

Montanelli et al. (2018): Discussed drugs and substances interfering with thyroid function, including testosterone.

Oliveira et al. (2019): Reviewed thyroid function disruptors, including the impact of testosterone on thyroid hormones.

Knezevic et al. (2020): Explored the thyroid-gut axis and how micro biota influences thyroid function. under the changing environmental condition, the physiological machinery to operate require adjustment without which the survival of the animals becomes impossible.

Crawford et al. (2016): Discussed testosterone replacement therapy and its role in pituitary and thyroid function.

Chaurasia et al. (2003): testosterone on thyroid gland activity in clarias batrachus.

Senthil Kumaran et al. (2001): Explored the impact of testosterone on thyroid function in catfish.

Temperature, Photoperiod seasonal variations are among the most important factors effecting the survival and metabolic activity of the fishes. This can be very judge & correlated with the climatic data shown in table.

Conclusion:

Testosterone propionate is an anabolic steroid and research on its impact on thyroid function especially in fish, is pretty-specific as clarias batarachus. Generally, steroids can influence thyroid function, but outcomes vary based on species, dosage, and duration.

Testosterone and thyroxine have significant effects on the thyroid gland of clarias batarachus.

REFERENCES

1. Backer Cohen (K.F), 1959: Renal and other beterotropic thyroid tissue in fishes. In Comparative Endocrinology P.P
2. Ball J.N (1960) Reproduction in female bony fishes. Sym. Zool. Soc. 1
3. Bearn (1964) H.A & JNandi: Endocrinology of poikilothermic vertebrates. In the hormones Ed. G. Pincus, K.V. Thimann & F.B. Astwood. 4,199-298. Academic Press New York and London.
4. Chaurasia et al. (1996): Studied lead-induced thyroid dysfunction in Clarias batrachus and found changes in T3 and T4 levels.
5. Crawford et al. (2016): Discussed testosterone replacement therapy and its role in pituitary and thyroid function.
6. Chaurasia et al. (2003): testosterone on thyroid gland activity in clarias batrachus.
7. Delsol M. & Flatin (1956) C.R. Soc. Biol. Paris 150 838 Vide T.P.Singh (1970) Ind. Biologist 2(1):1-15
8. Eales (1965) J.G. Factors influencing seasonal changes in thyroid activity in Juvenile steel head trout Salmogairdneri. Can J. Zool.
9. Gorban & bearn (1964) A text bookof Comparative Endocrinology. N.Y. John Weiley.
10. Hoar W.S. (1958) Effect of synthetic thyroxine and gonadal steroids on the metabolism of gold fishes. Can. J. Zool.
11. Hoar W.S. (1959) Endocrine factors in the ecological adaptation of fishes. In Comparative Endocrinology, ed. by A Gorbman, John Wiley & Sons. Inc. New York.
12. Khanna S.S. (1970). Endocrine glands. From An introduction to fishes. Central book Depot. Allahabad
13. Knezevic et al. (2020): Explored the thyroid-gut axis and how micro biota influences thyroid function.
14. Lehri G K. (1967) The annual cycle in the testis of the cat fish Clarius batrachus. Aeta, anat, Basel 69, 105-124.
15. Montanelli et al. (2018): Discussed drugs and substances interfering with thyroid function, including testosterone.

16. Nair P.R (1965) Study of the male reproductive system of some Siluriformes fishes. Indian J. Zool Vol. IV
17. Olivereau m.(1995) Higher thyroid activity in troutt lower temperatures. Arc. Anat. Micro. Morpho.
18. Oliveira et al. (2019): Reviewed thyroid function disruptors, including the impact of testosterone on thyroid hormones.
19. Pandey (1975), B.N. (1975): Studies on Endocrine factors in ecological adaptations & me-tabolism of a fresh water fish. Heteropneustus fossilis, Bhagalpur University, thesis, 1975.
20. Raizada (1975): The testicular cycle of a percoid teleost, Nandus nandus (Ham) Morphol. Jahrb, 121 (1): 77-87
21. Senthil Kumaran et al. (2001): Explored the impact of testosterone on thyroid function in catfish.

