EFFECTS OF VERTEBRATE STEROIDS ON THE INTERMEDIARY METABOLISM OF *T. MITRATUS*

Effect of Estradiol - 17B and Progesterone on some aspects of metabolism in an insect *Teleogryllus mitratus*

INTRODUCTION

Sex steroids have profound influence on growth and differentiation of reproductive structures of all organisms. The influence is very distinct in the tissues in which protein synthesis takes place. The steroids, especially estrogens, are well known for their ability to enchance protein synthesis in target tissues (Bentley, 1982). The level of nucleic acids are reported to be enhanced by the activities of estrogen in roosters (Bergink *et al* 1974). The yolk protein production is induced in the liver of oviparous vertebrates by the administration of estrogen (Tata 1970). In lizards, treatment with estradiol 17β induced enhanced protein and nucleic acid synthesis (Callard *et al* 1972 b). In an apodan amphibian *Gegeenophis carnosus*, the oxidative metabolism is significantly influnced by the administration of estrogen (Sudharam, 1990). The influence of estrogen in specific protein synthesis, is well demonstrated (Matty 1985). In a teleost fish *Anabas tesudineus* , the oxidative metabolism is influenced by estrogen administration (Peter *et al*,1989) . It is reported that in addition to reporductive centres, estrogen has pronounced influence on liver also (Medda *et al*, 1980).

The other steroid, progesterone, is found to be an inducer of vitellogenesis in several groups of fishes (Matty , 1985). In *Clarias batrachus and Clarias auratus* the level of triglycerides and phospholipids are enchanced by progestrone (Pal *et al* ,1987); Wiegand *et al*, 1980). The egg white protein synthesis in birds is regulated by progesterone (Baulieu, 1983) . The production of avidin and avidin mRNA is enchanced by the administration of progesterone in chick oviduct (Sperry *et al* 1976). Ovalution in amphibians is regulated by progesterone (Bergers *et al*, 1960).

The major steroids present in insects are ecdysteroids. Ecdysteroids perform various functions in insects. Examples are the Dictypteran, *Leucophaea maderae* (King *et al*, 1974), Orthoptera *Locusta migratoria* (Hoffmann *et al* 1975) *Gryllus bimaculatus* (Romer, 1977) Isoptera, *Bellicotermes* (Bordereau *et al*,1976), Lepidoptera, *Bombyx mori* (Karlson *et al*, 1956; Lecgay *etal*, 1976) *Galleria mellonella* (Hsioa *et al* ,1977) Dipteran, *Calliphora* (Shaaya *et al*, 1965) and *Aedes aegypti* (Schlacger *et al*,1974). In several specics like Blabera specics (Bulliere *et al*, 1976) ecdysteroids are found mainly in the developing embryo. High titres of ecdysteroids were found mainly in newly laid eggs of *Bombyx mori* (Ohmishi *et al* 1977a, Mizuno *et al* 1975). A study was conducted

in *Galleria mellonella* to determine the occurence and the quantity of different ecdysteroids in the ovary and egg, so as to assess their metabolic relationships. This species contains high titres of ecdysteroids in the ovary and eggs (Hsiao *et al* 1979). The ecdysteroids present in ovary are incorporated into the eggs. It is assumed that follicle cells are the site of production of ecdysteroids in *Bombyx mori* (Legay *et al*, 1976).

The discovery of ecdysteroids and their regulatory effect on ovarian development and ecdysis open a new area of scientefic research based on the elucidation, characterization and effects of mammalian steroids on arthropods, especially in insects. It was believed that ecdysteroid, the regulator of moulting, metamorphosis and reproduction in insects, is considered to be the only steroid hormone present in Arthropodes. But identification of other steroid hormones in arthropodes leads to the conclusion that the endocrine system of invertebrates and vertebrates are similar and complicated (De Loof *et al*, 1986).

As early as 1948, it was identified that estrogen was present in the eggs of American lobster *Homarus americans* (Donahue ,1948, 1957). Work done by Lisk (1961) confirmed this finding. Due to the advancement of biochemical tecniques like gas chromatography and mass spectrometry, it was possible to identify non-edysteroids in invertebrates. Using these modern

tecniques corticosteroids were traced in the haemolymph of *Gryllus domesticus* (Lehoux *et al*, 1970). De loof (1984) has identified several types of steroids in the haemolymph of the larvae of the flesh fly *Sarcophaga bullata* and Colorado potato beetle (Diederik *et al*, 1984). Mechoulam *et al* ,(1984) confirmed the presence of progesterone and estrogen in Sarcophaga. The presence of estrogen in the ovary of *Bombayx mori* is also established (Onishi *et al*,1985). Non-ecdysteroid steroids are also present in crustaceans. In *Astacus leptodactylus* several steroids ranging from pregnenolone to 6b-hydroxy progesterone were identified (Ollevier *et al*,1986). In Crustacea, testosterone was identified in male lobster serum and testes (Burns *et al*,1984).The presence of vertebrate type of steroids in insects was confirmed by several analytical methods (de Clerck *et al*, 1983, 1984; Onishi et *al*, 1985). The levels of vertebrate type steroids varies in different organisms. The titre of material which are positive to testosterone of the third instar larvae of *Leptinotarsa decemlineata* (de Clerck *et al*, 1988) was found to be 10 fold lower than the haemolymph extracted from adults and larvae of *Locusta migratoria* (Novak *et al*,1987). In some insect, the whole body extracts also contain ecdysteroids (Novak *et al*,1987). But the ecdysteroid titres fluctuate during various stages of its life history (Novak *et al*,1987, de Cleark *et al*,1987).

In recent years , a number of vertebrate hormones are reported in insect tissue and other invertebrates. Evidences are sporadically appearing about the presence of vertebrate type of steroids in insects and crustaceans (Goad 1976). One possible way of obtaining steroid hormones in insect is from plants. Estrogens are identified in several specics of plants (Geuns 1978). It was found that the estradiol obtained from plants are helpful in some phases of oocyte maturation in insects (de Clerk *et al*, 1984). Evidance is available of the presence of estradiol in the ovaries of *Locusta migratoria* (de Clerk and de Loof as cited by Onishi *et al*,1985). Kanazawa and Teshima (1971) injected cholesterol in to the spring lobster *P. japonica* and identified the presence of radio active testosterone, 17-a-hydroxyprogesterone and progesterone in the ovary. The presence of vertebrate type steroid hormones in marine invertebrate is well documented (Nikitina *et al*, 1977).

The vertebrate steroid hormones exert some important changes in *Drosophila* egg surface, the best studied example of hormone action, cAMP is clearly not a second messager for the steroid hormone response leading to changes in transcription in *Drosphila* (Jensen *et al*, 1972, O' Malley *et al*, 1974, Edelman, 1975). But some exception can be cited for this also. For example, the oocyte maturation was stimulated by progesterone in *Xenopus laevis* which bring about changes on the

surface of the oocytes and alters protein kinase activity through cAMP (Maller *et al*, 1977; Ishikawa *et al*, 1977; Godeau *et al*, 1978). But the evidence from *Drosophila melanogaster* suggests that the action of 20-hydroxy ecdysone is analogous to vertebrate steroid action which does not involve cAMP (Yund, 1979a). cAMP was found to enhance the hormonal influence by enhancing steroid hormone activity for puff formation in *Drosophila ludei* (Leenders *et al* 1970).

The general functions of insects steroid are known. But the influence of vertebrate sex steroids in insects remains to be clearly understood. As a preliminary step, I have studied the effects of vertebrate steroids like progesterone and estradiol on the fat body, ovary and haemolymph of *T mitratis*.

MATERIALS AND METHODS

Second wing nymphs were collected from the culture and kept in seperate containers for adult emergence. 48h old adult insects were selected. Estradiol- 17B 1µg, 3µg, 5µg / insect were injected. Progesterone 1µg , 3µg and 5µg / insect were injected, to another set of 48h old adults. The controls received vehicle injection. Tissues were taken 48, 72, 96, 120 and 192 h after the administration of the hormones. The enzyme

EFFECT OF ESTARADIOL ON THE FAT BODY OF T.mitratus (mean + S D)

TABLE 4

	Protein				AST				ALT			
	C	1µg	3µg	5µg	C	1µg	3µg	5µg	C	1µg	3µg	5µg
48	9.92± 3.29	10.16± 3.41*	16.70± 4.22 b	17.27± 5.06 b	2.72± 0.27	2.61± 0.40	2.97± 0.12a	3.58± 0.06	3.49± 0.32	3.50± 0.35	4.05± 0.04	5.54± 0.23 b
72	6.08± 1.24	6.21± 1.02	13.41± 3.45 b	18.86± 5.24 b	3.58± 0.36	3.58± 0.32	3.48± 0.06*	3.89± 0.18*	6.47± 0.08	6.46± 0.12	6.66± 0.14	7.03± 0.05 b
96	10.84± 2.80	10.95± 2.73	19.81± 6.08	23.18± 6.80 b	3.50± 0.29	3.53± 0.34	4.35± 0.04	4.88± 0.04 b	6.79± 0.13	6.79± 0.18	7.01± 0.12	7.93± 0.06 b
120	16.27± 4.41	16.52± 4.66*	21.81± 6.32	29.42± 7.43	3.93± 0.08	3.95± 0.11	4.68± 0.08	6.01± 0.03 b	7.12± 0.04	7.12± 0.09*	7.76± 0.12	8.43± 0.17 b
192	19.83± 4.47	19.73± 4.56*	22.63± 6.58	32.13± 9.99	4.09± 0.10	4.10± 0.08	4.78± 0.30	7.12± 0.04a	7.25± 0.04	7.25± 0.11*	7.85± 0.04	9.04± 0.04 b

a $p < 0.05$
b $p < 0.001$
* non significant

Protein µg/mg tissue
AST IU/mg wet wt.
ALT IU/mg wet wt.

EFFECT OF ESTRADIOL ON THE OVARY OF T.mitratus (mean + S D)

TABLE 5

	Protein				AST				ALT			
	C	1Mg	3Mg	5Mg	C	1Mg	3Mg	5Mg	C	1Mg	3Mg	5Mg
48	11.59±	10.89±	9.11±	7.24±	3.69±	3.62±	2.66±	1.69±	8.45±	8.44±	7.45±	4.26±
	3.13	3.19*	3.20	2.24	0.11	0.26	0.21	0.17	0.17	0.22*	0.40	0.13
72	15.47±	15.57±	12.93±	9.32±	4.73±	4.74±	4.20±	3.00±	8.70±	8.68±	7.86±	4.65±
	4.95	4.76*	3.98	2.77	0.28	0.35*	0.12	0.50	0.10	0.15*	0.07	0.07
96	18.26±	18.13±	14.62±	11.41±	4.93±	4.92±	5.04±	3.69±	8.80±	8.83±	8.22±	4.90±
	5.73	5.63*	3.69	3.1	0.07	0.14*	0.25*	0.53 b	0.06	0.11*	0.10	0.13
120	21.01±	21.10±	18.43±	14.71±	8.68±	8.61±	7.20±	5.07±	8.94±	8.94±	8.44±	5.08±
	5.88	6.19	5.00	3.87	0.09	0.45*	0.14	0.16b	0.08	0.07*	0.08	0.08
192	24.36±	24.30±	19.66±	17.71±	9.48±	9.55±	7.99±	5.59±	9.25±	9.31±	9.01±	5.70±
	6.01	6.08*	5.60	4.22a	0.11	0.18	0.06	0.07b	0.06	0.10*	0.02	0.11

a $p < 0.05$
b $p < 0.001$
* non significant

Protein µg/mg tissue
AST IU/mg wet wt.
ALT IU/mg wet wt.

EFFECT OF ESTRADIOL ON THE HAEMOLYMPH OF T.mitratus (mean + S D)

TABLE 6

	Protein				AST				ALT			
	C	1µg	3µg	5µg	C	1µg	3µg	5µg	C	1µg	3µg	5µg
48	3.71± 1.14	3.71± 1.28 *	3.51± 1.18 *	1.01± 0.57 b	3.01± 0.40	3.09± 0.40 *	2.30± 0.15 b	1.03± 0.02 b	3.29± 0.38	3.22± 0.40 *	2.30± 0.20 b	1.66± 0.08 b
72	7.21± 2.41	6.85± 2.43 *	4.85± 1.97 a	2.10± 0.80 b	3.90± 0.24	4.01± 0.16 *	3.14± 0.11 b	1.81± 0.10 b	4.28± 0.27	4.45± 0.44 *	2.74± 0.09 b	1.86± 0.06 b
96	9.55± 2.85	9.56± 2.89 *	8.19± 3.03 *	4.16± 1.38 b	4.88± 0.10	4.96± 0.07 *	3.90± 0.05 b	1.96± 0.04 b	4.49± 0.09	4.57± 0.27 *	3.00± 0.04 b	2.13± 0.05 b
120	13.04± 3.83	13.06± 3.75 *	9.56± 2.70 *	4.29± 0.91 b	4.99± 0.06	4.93± 0.10 *	4.05± 0.08 b	2.05± 0.05 b	4.81± 0.11	4.80± 0.19 *	3.27± 0.04 b	2.28± 0.04 b
192	15.30± 4.69	15.28± 4.71 *	10.57± 3.79 *	6.22± 1.10 b	5.22± 0.04	5.15± 0.16 *	4.19± 0.07 b	2.23± 0.07 b	5.08± 0.06	5.06± 0.11 *	3.37± 0.08 b	2.68± 0.09 b

a $p < 0.05$
b $p < 0.001$
* non significant

Protein µg/mg tissue
AST IU/mg wet wt.
ALT IU/mg wet wt.

EFFECT OF PROGESTRONE ON THE FAT BODY OF T.mitratus (mean + S D)

TABLE 7

	Protein				AST				ALT			
	C	1µg	3µg	5µg	C	1µg	3µg	5µg	C	1µg	3µg	5µg
48	6.27± 2.30	7.32± 2.37 ✱	11.66± 4.75	13.97± 3.88 b	1.43± 0.24	1.88± 0.27	2.86± 0.37 b	5.06± 0.49 b	2.05± 0.36	2.51± 0.23	3.61± 0.31 b	4.52± 0.39 b
72	7.40± 2.52	8.22± 1.40 ✱	11.41± 2.01	16.89± 5.65 b	2.05± 0.36	2.13± 0.15	2.98± 0.42 b	5.25± 0.28 b	2.00± 0.20	2.38± 0.19 a	3.33± 0.16 b	4.01± 0.30 b
96	9.89± 2.83	10.20± 1.24 ✱	16.28± 4.46	19.31± 5.00 b	2.43± 0.24	2.46± 0.25 ✱	3.73± 0.50 b	5.60± 0.74 b	2.18± 0.09	2.26± 0038	3.80± 0.36 b	4.20± 0.23 b
120	11.77± 3.66	11.98± 3.15 ✱	18.30± 3.31	20.60± 5.18 b	2.91± 0.19	3.13± 0.28 ✱	4.11± 0.35 b	6.23± 0.30 b	2.31± 0.21	2.36± 0.39 ✱	4.55± 0.32 b	5.03± 0.35 b
192	15.98± 5.97	15.97± 5.09 ✱	21.87± 4.17	25.53± 6.16 b	3.23± 0.23	4.01± 0.45 ✱	4.88± 0.38 b	6.86± 0.30 b	3.00± 0.41	3.16± 0.30 ✱	3.50± 0.42 b	5.35± 0.24 b

a $p < 0.05$
b $p < 0.001$
✱ non significant

Protein µg/mg tissue.
AST IU/mg wet wt.
ALT IU/mg wet wt.

EFFECT OF PROGESTERONE ON THE HAEMOLYMPH OF T.mitratus (mean + S D)

TABLE 8

	Protein				AST				ALT			
	C	1µg	3µg	5µg	C	1µg	3µg	5µg	C	1µg	3µg	5µg
48	5.03±	4.94±	3.41±	2.22±	3.26±	3.16±	2.26±	1.48±	2.08±	2.11±	1.20±	0.88±
	1.55	1.46*	1.29 a	1.06 b	0.39	0.54*	0.28	0.22 b	0.31	0.28	0.21 b	0.14 b
72	5.68±	5.71±	3.87±	2.82±	3.20±	3.26±	2.93±	2.11±	2.78±	2.90±	1.41±	0.90±
	1.82	1.73*	1.14 a	0.96 b	0.44	0.61*	0.48 b	0.49 b	0.51	0.62	0.24 b	0.17 b
96	7.91±	8.10±	4.40±	3.78±	3.98±	4.01±	2.95±	2.75±	3.46±	3.15±	2.38±	1.31±
	1.92	1.99*	1.15 b	1.18 b	0.26	0.46*	0.26 b	0.42 b	0.34	0.67	0.34 b	0.31 b
120	9.59±	9.75±	7.86±	5.78±	5.88±	5.48±	4.43±	3.53±	4.16±	4.16±	2.96±	1.41±
	2.74	2.27*	2.22*	0.93 b	1.12	0.68 *	0.25 b	0.24 b	0.37	0.40	0.28 b	0.24 b
192	11.16±	11.36±	7.70±	6.14±	5.68±	6.00±	5.05±	4.65±	5.35±	5.25±	3.50±	1.51±
	3.11	3.74*	1.05	2.10 b	0.47	0.67*	0.36	0.35 b	0.38	0.34	0.37 b	0.25 b

a $p < 0.05$
b $p < 0.001$
* non significant

Protein µg/mg tissue.
AST IU/mg wet wt.
ALT IU/mg wet wt.

EFFECT OF PROGESTERONE ON THE OVARY OF T.mitratus (mean + S D)

TABLE 9

	Protein				AST				ALT			
	C	1mg	3mg	5mg	C	1mg	3mg	5mg	C	1mg	3mg	5mg
48	5.80±	6.12±	3.51±	1.71±	3.45±	3.60+	2.36±	1.38±	3.41±	3.76±	1.86±	1.20±
	1.90	2.48 *	1.37	0.67 b	0.36	0.24 *	0.20 b	0.27 b	0.496	0.52	0.53 b	0.42 b
72	7.55±	7.44±	3.97±	2.70±	4.28±	4.38±	2.73±	1.26±	4.43±	4.41±	2.81±	1.88±
	2.05	1.64 *	0.91 b	1.00 b	0.37	0.43 *	0.48 b	0.10 b	0.46	0.30 *	0.57 b	0.30 b
96	8.70±	8.39±	5.56±	3.94±	5.40±	5.51±	3.41±	2.55±	5.40±	5.46±	3.35±	2.38±
	1.39	1.39 *	0.94 b	1.34 b	0.25	0.26 *	0.28 b	0.36 b	0.40	0.45 *	0.20 b	0.43 b
120	10.36±	10.10±	8.16±	3.78±	6.13±	6.16±	3.41+	2.05±	5.81±	5.86±	4.35±	2.65±
	2.28	2.42 *	1.94 a	1.14 b	0.37	0.39 *	0.24 b	0.43 b	0.34	0.30	0.30 b	0.18 b
192	12.43±	12.38±	9.69±	6.18±	6.88±	7.18±	5.40±	3.55±	7.71±	5.58±	3.73±	1.93 ‡
	3.20	3.17 *	2.01 b	2.12 b	0.28	0.46 *	0.23 b	0.27 b	0.44	0.49	0.30 b	0.45 b

a $p < 0.05$
b $p < 0.001$
‡ non significant

Protein µg/mg tissue
AST IU/mg wet wt.
ALT IU/mg wet wt.

activities and levels of proteins in fat body , ovary and haemolymph were determined as mentioned earlier. Statistical analysis was done as discussed before.

RESULT

The results of analysis of various tissues are presented in Tables (4-9).

The administration of estrogen and progesterone showed some important changes in the level of proteins and enzymatic activities. In the fat body of control insects, the protein levels showed an age wise increase from 96h to 240h. Same pattern was followed by the experimental insects. Here also an age dependent increase was observed in the protein levels. Here a dose dependent increase of protein by the administration of progesterone and estradiol was observed in the fat body. The increase was highly significant in 3µg and 5µg/ul administered insects.

The transaminases, both alanine amino transferase (ALT) and aspartate aminotransferase in fat body showed a general increase in their activities from 98h to 120h in the control organisms. In the experimental insects also same patterns of increase was observed. The increase was more

significant in 3ug and 5ug estradiol or progesterone treated insects.

In the ovary, an age-dependent increase was observed in the protein levels of control as well as in experimental insect from 96h to 240h. When the control insects are compared with the experimental insects, a dose dependent decrease was observed in the protein levels of the experimenal insects. Higher doses produce more effects.

The activity of both the transaminases decreased by the administration of progesterone and estradiol. The decrease was marked in 5µg treated insects. In the ovaries, progestrone and estradiol produced their effects on a dose dependent manner.

In the haemolymph of the control as well as experimental insects, an age wise increase of transaminase activity was observed from 96h to 240h .But when the controls and experimentals are compared, a dose dependent decrease was observed in the experimental insects. The decrease was significant in 5ug/ul progesterone treated insects. The activity of transaminases showed an age wise increase from 96h to 240h in experimental and control insects. When a comparison was made between the experimental and contorl insects a dose dependent decrease was observed in the experimental insects and significant decrease was observed in 5 / µl treated experimental insects.

In general, the administration of these steroids, progesterone and estradiol, produced a stimulatory effect in fat body by increasing the level of protein and enzymatic activities but showed an inhibitory effect in haemolymph and ovary by decreasing the level of protein and transaminase activity.

Different tissues have differential responses to the injection of steroid hormones. In fat body, ovary and haemolymph of *Teleogryllus*, there was an age dependent increase in protein level and enzyme activities. The treatment of hormone brought about an increase in the levels of protein and enzyme activities in fat body. When comparisons were made between experimental and control at different age groups, in the ovary and haemolymph, eventhough an age dependent increase was observed in protein and enzymes, a distinct dose dependent decrease was observed in protein levels and enzyme activities of hormone treated insects.

DISCUSSION

In arthropods several steroids other than ecdysteroids are identified. The presence of estrogen and progesterone is reported in the serum of American lobster

Homorus americans (Burns *et al*, 1984), Androgens and estrogens are found in *Periplaneta americana and Manduca sexta* ;*Tenebrio molitor and Sarcophaga bullata* by Machoulam *et al* (1984). Titres of several steroids are measured in the purified samples of *Locusta migratoria* (Nowak *et al*, 1987). All these observations clearly demonstrate the presence of vertebrate type of steroids in arthropods especially in insects.

In *Teleogryllus mitratus*, the steroids estradiol and progesterone show significant effects in the levels of protein content and transaminases activity. In the fat body, the activity of both ALT and AST show an age wise increase from 48h to 192h in the control specimens. However treatment of 3ug and 5ug estradiol or progesterone increases the activity of these enzymes at all age intervals studied. This increase indicates the stimulatory effect on gluconeogenesis as these enzymes converts L- alanine and L-aspartate into corresponding intermedieries of carbohydrate metabolism. The levels of proteins also show a same type of increase. The increase is probably due to the stimulation of increased protein synthesis. The increased protein synthesis is also a pre requisite for gluconeogenesis since the enzyme to stimulate the process are proteins.

Gluconeogenesis is the ability of the organism to synthesize carbohydrates from non-cabohydrate precursors (Lehninger 1975). In insects the major substrates for gluconeogenesis are amino acids, which on degradation liberate pyruvate as any other intermediates and glycerol. The ability of the insects to produce carbohydrate from amino acids was reported by Wigglesworth (1942). In *Aedes aegypti*, feeding alanine or glutamate to previously starved mosquitoes increases the glycogen content. Labelling experiments have shown the incorporation of isotopes into carbohydrates from labelled amino acids, (Lipke *et al*,1965), Pyruvate (Bricteusx- Gregoire *et al*, 1964) and glycerol (Candy *et al*, 1976). The activities and intracellular distribution of the key enzymes in the fat body were measured in *Locusta migratoria*, (Storey and Bailey, 1978 b).

In the haemolymph of *Teleogryllus* there is a dose dependent and time dependent decrease in the level of protein and the activity of enzymes. The reduced activity of AST and ALT are due to the non-availability of substrats- aspartate or alanine in the haemolymph. The decrease in the protein content in the hormone treated insects probably indicates the reduction in protein synthesis or mobilization of protein from the haemolymph to fat body.

In insects, degradation of amino acidtakes place through a specific system to liberate acetyl co-A, pyruvate or an

intermediate of the tricarboxylic acid cycle (TCA cycle). During degradation, breakdown or removal of the amino group by transamination or oxidation takes place. Degradation of amino acid for gluconeogenesis is likely to be of physiological importance during starvation. When the locust *Schistocerca gregaria* was starved, there was a drop in its protein content in the haemolymph; while the amino acid content becomes doubled. This gives a strong evidence that haemolymph proteins are converted into amino acids during starvation (Hill *et al*, 1966). It was also believed that muscle proteins are broken down during starvation in *Locusta migratoria* (Hill *et al*, 1970).

Some authors are of the opinion that vertebrate steroids especially estradiol and progesterone, do not play any significant role in the activities of ovaries of lower organisms (Ogiso *et al*, 1986). But the decrease in the ovarian protein by progesterone was reported in prawn (Kulkarni *et al*,1979) and in insects (Novak *et al*, 1987).

In *Teleogryllus*, the ovary shows a decrease in the activity of AST and ALT by the administration of steroid hormones. The protein levels also decrease . The decrease was marked in 5μg treated insects when compared to the controls. This is probably due to the inhibition of gluconeogenesis and increased breakdown of ovarian protein. In other words the inhibitory effect on transaminase activity due to the

administration of steroids, probably increases the amino acid metabolism.

The action of steroids on higher and lower vertebrates are well documented. In rats, administration of estradiol leads to decrease in gluconeogenesis. (Matute *et al*,1973). The enhancement of protein synthesis by the administration of estrogen in various oviparous vertebrates was noticed (Plack *et al*, 1971; Chester John *et al*, 1972;Craik, 1978; Emmerson *et al*, 1971). Increase in the protein content by the administration of estradiol is reported in female singi fish (Medda *et al*, 1979). Estrogen mediates the synthesis of protein in flounder (Emmersen *et al* ,1976) and in Cod (Plack *et al*,1971). In higher vertebrate like rabbits, rats and amphibia, administration of progesterone increases the synthesis of protein (Zwierzowski *et al*, 1987; and Gordeau *et al*, 1978). In rats administration of steroids tends to decrease the activities of both AST and ALT (Matute *et al*, 1973).

Several authors have reported the response exhibited by lower organisms to vertebrate steroids. Marine Penaied prawn *Parapenaeopsis hardwickii* when treated with different doses of progesterone show an increase in oocyte size, and ovarian protein levels (Kulkarni *et al* ,1979). The conversion of progesterone in the ovaries of crab *Portunus*

trituberculatus was earlier reported (Shin- Ichi *et al*, 1971). In this organism, the ovaries are capable of converting progesterone to 17 a- hydroxy progesterone, tesosterone and deoxicorticosterone (Shin-Ichi, 1971). In sea urchin and oyster gonads, the steroid- estradiol 17B is converted to estrone and testosterone to androsterone (Hathaway, 1965). In lobster *Homarus americans*, androsterone is converted to testosterone (Idler *et al* 1969). The active part played by steroid hormones in the reproduction of vertebrates is well known (Khoo, 1979). In lower organism like crustaceans also, steroids are necessary for reproduction and ecdysis (Adiyodi ,1978; Stevenson *et al* ,1979). The effects of steroid hormone administration in the process of gametogenesis was reported in several invertebrates (Bomirski *et al*, 1976;Sarojini *et al*, 1985; Sambasiva rao *et al*, 1985).

In crustaceans, the presence of steroid hormones and enzyme system for metabolizing them was discovered (Kanazawa *et al* 1971; Teshima *et al*, 1970, 1971a, b). Sarojini *et al*, (1990) found that administration of estradiol and estrone leads to increase in the size of the oocytes. Similar type of observations are made in *Macrobrachium lamerri* (Sarojini *et al*, 1984),and in *Ceangon crangon* (Bomirski *et al*, 1976).

The cytochrome P 450, found in mammalian microsomes present in vertebrate, has the capability of hydroxylating testosterone (Wood *et al*, 1983; Jannson *et al*, 1985). Recently, it was reported in *Drosophila melanogaster* that microsomes are capable of hydroxylating testosterone (Cuany *et al*, 1990). In another experiment it was found that the metabolism of testosterone was enhanced by microsomes of insecticide- resistant *Spodoptera littoralis* larvae. In this, occurance of NADPH- dependent testosterone hydroxylase activity in microsomes was found (Lagadic *et al* 1993).

The physiological role of vertebrate steroids in insects is still not clear. It is evident from the present studies that both estrdiol and progesterone have some regulatory effect on the metabolic pathways of the insects. These steroid hormones enhance the metabolic activity of fat body, by inducing the level of protein and transaminase activities. In other wrods,there is greater gluconeogenic and proteogenic activity in the fat body, when this tissue was stimulated by steroid hormones. But in haemolymph and ovary these steroids produce an inhibitory effect in protein levels and the activity of the transaminases.