INTRODUCTION

It is a well known fact that most of the birds show a regular pattern of activities like migration, moulting, breeding, etc. with certain periodicity. These activities are influenced by environmental factors (ultimate) such as day length, temperature, rainfall etc.. Ability to adjust to such various environmental conditions permits the birds to adapt to particular activity schedules and habitat in such a way so as to carry out various life activities in suitable patterns at optimal conditions. Continuation of generation being the prime phenomenon of life, it gets the top most priority among all such various adaptions. Hence, majority of the birds try to breed at such time of the year when environmental conditions are maximally favourable for breeding activity as well as consequent nurturing of youngones (Lack,1950). Further, Immelmann (1971) also enjoined that majority of the birds living in non-uniform temporal patterns of energy requirement depend for their survival on the development of the efficient timing programmes that permit the adjustment of physiologically important functions to favourable periods. Immelmann (1971) has remarked that because of its heavy physiological demands reproduction is most critical among the recurrent events and must be timed to a period of minimum stress on the adults and

maximum probability for the survival of parents as well as youngones.

Other than the domesticated species, many species of columbiformes growing in urban areas, where food is available throughout the year, show more or less continuous breeding activity (Lofts, 1966). Birds residing in tropical countries, where environment is almost uniform throughout the year, also show continous breeding patterns (Immelmann, 1971). In this context, the work of Kotak (1979) on breeding activity of feral pigeon populations in and around Baroda city (tropical India) becomes worthy of notice. He has demonstrated that the feral pigeons exhibit annual bimodal-pattern of reproduction with noticeable periods of non-breeding. However, when considered on the population level, individual pairs of birds were found to schedule their breeding activity anywhere over the wider spectra of breeding seasons, give an impression of apparent continuous breeding activity over the year.

Duration of the day light is known to play an important role in the breeding activity. Benoit (1964) has emphasized on the importance of photoperiod as the regulatory factor which involves retino-hypophyseal complex. Further, Vinod Kumar (1986) has reported carryover effect of long photo-periods on the fattening and gonadal response in photo-periodic migratory species of finch - the black-headed bunting (Emberiza melanocephala). Chaturvedi and Thapliyal

(1980) have reported the relation of thyroid, photoperiod and gonadal regression in the common myna, Acridotheres tristris. Thus the functional and nonfunctional states of gonads are under the influence of environmental factors.

Majority of birds from temporate zone, except few urbanized species, prefer long summer days for breeding and show distinct breeding and nonbreeding seasons throughout the year, interrupted by distinct regressive and recrudescent phases. Gonads develop into comparatively voluminous organs during breeding season with gametogenesis as well as steroidogenesis and regress remarkably during non-breeding season; when gametogenesis does not occur (Marshall, 1961 and Nalbandov, 1970). In any case there is spontaneous progression from recrudescence to acceleration phase (which is referred to as Pre-breeding phase - PR in the present work). During this phase the concerned hormones start getting secreted in gradually increasing amounts. These changes will have varied physiological and behavioral effects which are of great reproductive significance (Nalbandov, 1970; Lofts and Murton, 1973; Pfaff and Schwart-Giblin, 1988 and Sachs and Meisel, 1988). Such alterations in the levels of hormones lead to alteration in the structural properties and biochemical milieu of various organs and tissues of the body concerned with reproductive systems.

Since a lot of work has been done on some continuous breeders such as domestic chicken (Nakamura and Tanabe, 1972; Wells et al., 1983 and Armstrong, 1985) and columbid birds (Frith et al., 1976; Kotak, 1979; Lofts et al., 1966, 67; Murton, 1958 & 60; Murton et al., 1973), it was thought desirable to investigate seasonal changes in some of the structural and biochemical parameters in two closely related wild species of mynas viz. - Bank myna Acridotheres ginginianus and Brahminy (black-headed) myna Sturnus pagodarum (Family : Sturnidae) which show distinct breeding and non-breeding phases. Though, both these species are reported to be hole-nesting species, Bank myna is colonial breeder, nesting in the tunnels excavated in ravines, wells or even under the bridges, whereas the Brahminy myna is an individual nester, nesting in holes in the trees, in open ends of electricity poles, available holes in houses and of course the nest boxes. Both these species are reported to be omnivorous (Ali, 1979). Bank myna has been observed to feed on even the human left overs, whereas Brahminy myna feeds only on fruits/insects.

For the sake of convenience of discription and discussion reproductive cycles of these two species of birds have been divided, grossly into following four phases of the annual cycle :- pre-breeding phase (PR), breeding phase (BR), post-breeding phase (PS) and non-breeding phase (NB). Both these species breed in long

Plate I : Photographs showing Bank myna in natural surroundings.

Plate I

Plate II : Above : Two birds seen picking up human left-overs from garbage.

Below : Bank myna colonising the holes in the wall of the bridge.

Plate II

Plate III : Above : A generalized view of riverine nest colony of Bank myna.

Below : A close up of the colony showing a Bank myna at the entrance of nest hole.

Plate III

Plate IV : Above : Brahminy myna in its natural surroundings.

Below : Normal foraging activity of Brahminy myna.

Plate IV

Plate V : Showing nesting behaviour of Brahminy myna in the open end of an electric pole.

Plate V

Plate VI : A parent bird feeding the fledglings.

Plate VI

Plate VII : A parent bird feeding the fledglings.

Plate VII

summer days - Bank myna from May to September and Brahminy myna from April to August, in Baroda city (Longitude 72.3° 13'E, Latitude 22° 18'N).

In male as well as female birds of both these species the following organs were chosen for the present work - (i) liver, (ii) blood/blood plasma, (iii) kidney, (iv) proximal part of jejunum and (v) gonads. Various parameters studied quantitatively were (a) ascorbic acid, (b) total lipids, (c) glycogen, (d) total proteins content and (e) cholesterol - total as well as esterified. In addition to these, gross body weight, weight of the ovary and the gonosomatic indices (GSI) were also recorded throughout the work, with a view to acquire basic information for reference.

Ascorbic acid (AA) - Vitamin C, is known to play varied significant roles in the general body metabolism and more particularly in steroidogenesis. As regards the first point, AA by virtue of its capacity to form reversible oxidation-reduction complexes of monodehydro-ascorbate (MDHA) are known to fecilitate several metabolic processes involving transfer of electrons. Further, it is well known that AA, monoascorbate and dehydroascorbate are also intimately involved in the steroidogenesis (Szent Gyorgii, 1957; Bacq and Alexander, 1961; Chinoy and Rao 1979). Based on their work on testis of Toad, Biswas (1969), and

Biswas and Deb (1970) have shown that dehydroascorbate activates the enzyme activity of Δ^5-3β-hydroxysteroid dehydrogenase (Δ^5-3β-HSDH), one of the key enzymes responsible for several steps in the interconversions of steroid metabolites. Chinoy and Seethalaxmi (1978) have reported an inter-relationship between the tissue levels of AA and testosterone in case of albino rats. It has also been known that testosterone and human chorionic gonadotropin influence the enzymes involved in the metabolism of L-AA in rats (Majumdar and Chatterjee, 1974). In this light, AA levels were measured in the present work.

Liver and/or kidney is/are known to be the site(s) of AA synthesis in several bird species (Roy and Guha, 1958). Nagorna-Stasiak et al. (1986) have observed that when low concentration of AA was given in diet to chicken AA was absorbed actively and at higher dietary concentration the absorption was passive. In the light of above information it was thought desirable to find out changes in AA levels of different tissues including jejunum so as to see if there is any significance in the present context.

Though the dietary cholesterol is absorbed through intestine (Moringa Osamu, 1987; Horii Yuji, 1987), it is known to be synthesized mainly in the avian liver (Yeh and Leveille, 1973; Griminger, 1976) as well as to a certain extent in the skin and intestine of chicken (Yeh and

Levaille, 1973). Cholesterol serves as the chief precursor, apart from its involvement in several other metabolic processes, for adrenal as well as gonadal steroid hormones (Bloch, 1945; Zaffaroni et al., 1951; Hetcher, 1953; Hayno et al., 1956; and Heard et al., 1956; Smith et al., 1985). Presence of important metabolites of steroid pathways such as cholesterol and pregnenolone (Furr, 1969, 70), progesterone (Furr, 1969,70; Dick et al. 1976; Bahr et al., 1983; Wells et al., 1983; Asem et al., 1965; Robinson and Etches, 1986) and of the key enzyme 3 -HSDH (Botte, 1963; Chieffe and Botte, 1965; Wyburnan and Baillie, 1966; Armstrong et al., 1977; Armstrong, 1985), have been demonstrated in the chicken ovary. Hence total and esterified cholesterol contents were measured in various tissues.

It is well known that gonadal lipids show well defined variations in accordance with their functional and regressed states in case of fishes, amphibians, reptiles, birds and seasonally breeding mammals. Hence, the gonadal lipids were estimated, and, with a view to find out its possible relations with other tissues, total lipids were also measured in all tissues mentioned earlier.

Glycogen, the main energy reserve, is known to cater to the overall energy demands related to general metabolism of an organism, by releasing glucose in the blood plasma.

It is known to be chiefly synthesized in the liver. In addition to this, as far as the avian group is concerned, kidney is also reported to actively participate in gluconeogenesis, as well as providing glucose to the blood at least in some species of birds (Krebs and Yoshida,1963; Watford et al., 1981; Mehta, 1985). Presence and involvement of glycogen in the various cellular elements of testis (Free, 1970) and ovary (Bjersing, 1977) have been well documented. From above cited references it was clear that localization and distribution of glycogen follow certain definite patterns complementary to the processes of spermatogenesis and ovarian follicle and oocyte development. The presence of glycogen in sertoli cells is related to its role in providing nurishment to the developing germinal epithelial elements. Ovaries also have different types of cells which show variations in glycogen content according to developmental stages of ovarian follicles as well as oocytes and the production of ovarian hormones. As the seasonal development of gonads and its functional state is under influence of environmental changes in many species, in which gonads develop considerably in weight and volume during breeding and regress during non-breeding season, it is logical that carbohydrate metabolism could vary in different cellular elements of gonads with respect to different phases of reproductive cycle. Taking into consideration the above mentioned facts, it was

thought desirable to investigate changes taking place in glycogen contents in the liver, gonads, kidney as well as intestine. Intestine was included here as it is an inward gateway for all nutritive materials. Kerstin Uvnäs-Moberg (1989) has discussed the importance of G.I.tract with respect to reproduction. According to her, the G.I.tract is the largest endocrine gland in the body, and the various hormones produced by it exert profound influences on digestion, metabolism as well as emotions and behaviour. The organism undergoing reproduction is usually in greater need of food, which is so important that normal reproduction simply does not take place in the absence of adequate nutritional elements. Reproduction is always preceded by a period of increased uptake and storage of energy, when changes in the hormone activities of G.I.tract play a significant role. G.I.tract needs to function optimally during the period of reproduction. Similarly in case of domestic fowl it has been reported that egg laying is held in abeyance due to starvation (Nalbandov, 1970). In birds also, demand for food is particularly higher during the period of reproductive season, more so in case of female birds where the high rate of production as well as deposition of significant amount of yolk and physical energy needed for nurturing youngones is comparatively high. While investigating the changes taking place in liver and gonad, curiosity arose to find out simultaneous

changes taking place in the intestine as well. Due to some practical difficulties it was not possible to investigate simultaneous changes taking place in blood glucose levels too, which otherwise would have gone a long way for far better interpretation of data resources in the present investigation.

Various types of proteins are known to be secreted by different cells of the testes. Sertoli cells secrete a variety of polypeptides as well as the androgen binding protein (ABP) (French and Ritzen, 1973; Steinberger et al., 1975; Feldman et al., 1981; A polypeptide-pro-opiomelanocortin- found in leydig cells, has been shown to serve as precursor for a number of secretary peptides of different cells (Bardin et al., 1987). Testis being meotically active organ, several relevant proteins are also synthesized in the testis. Similarly, ovary being meotically active needs to synthesize particular proteins associated with the process. Ovaries also have to adapt to quick and phenomenal deposition of proteo-lipids of yolk, mobilized mainly from the hepatic tissue. These highly significant metabolic events would, of necessity, lead to important alterations in total protein content within the ovaries and elsewhere. Hence, the third major organic component - the protein - was also assessed in all the tissues mentioned, except blood, during different phases of reproductive cycle.

Apart from the lack of data on blood glucose levels stated a while before histoenzymological observations on some important enzymes as well as histological observations on the functional and otherwise state of gonads would have added significantly to the much desirable complimentary information. However, within the limitations of the work for a thesis of the present dimensions, it was not possible to cover all these points. Nevertheless, the author is hopeful enough to carry out the said work in near future, as and when opportunity comes by.

CHAPTER I

SEASONAL VARIATIONS IN TOTAL LIPID CONTENT, BODY WEIGHT AND GONADAL WEIGHT IN TWO SPECIES OF MYNA AS RELATED TO REPRODUCTIVE CYCLES

The basic rhythmic pattern of reproductive activities is repeated in case of birds also. In general, the seasonal fluctuations in environmental factors like light, temperature, rainfall, availability of food, etc. are known to influence the gonadal functions, particularly in temperate zone species. Such seasonal changes obviously act on the central nervous system leading to stimulation of release of gonadotropins from the adenohypophysis. In all of the vertebrates it is known to be mediated by liberation of neurohumoral factors from the hypothalamic nuclei and transported to portal vessels via median eminence and thence to the pars distalis. Thus, the neuroendocrine system constitutes a finely integrated and balanced co-ordinating system between the environment and the organisms.

According to David Lack (1950) majority of animals normally breed at such times of the year when availability of food is maximum and other environmental conditions are favourable for survival of youngones. Immelmann (1971) added a rejoinder that as reproduction puts heavy

physiological demands on the organisms, the same must be timed to a period of minimum stress on adults and maximum probability for raising the young.

According to Benoit (1964) daylight is an important factor which involves retino-hypothalamo-hypophyseal axis. When the daylight is available for longer duration, foraging activity of parents is also increased, and hence, the chances that the youngones will get more nourishment are ensured. Several other workers have also reported influences of light (Wolfson, 1960; Farner and Follett, 1966; Lofts et al., 1967; Lofts, 1970; Follett and Davis, 1975; Kumar Vinod, 1986; Brain et al., 1988), temperature (Burger, 1948; Farner and Mewaldt, 1952; Engels and Jenner, 1956; Farner and Wilson, 1957) and rainfall (Wingfield, 1984) on the breeding activities. Marshall (1949) and Lofts and Murton (1966) have related embient temperature and rates of testicular development. Further, it has also been reported that lack of suitable nesting site retards the development of gonads. Thus, a correlation between environmental factors and gonadal activity has been well established.

Most species of birds, except few domesticated species like fowl and some urbanized columbids (which get continuous food supply throughout the year) and some tropical birds, show distinct breeding and non-breeding

seasons. As in other vertebrates, avian gonads are also responsible for gametogenesis and sex hormone synthesis. Gonads are known to undergo cyclic structural and functional changes from breeding phase (BR) to non-breeding phase (NB) and back to breeding (Marshall, 1961 and Nalbandov, 1970) interspersed with postbreeding (PS) and pre-breeding (PR) phases. The cyclic changes in size and activity of gonads and hormonal levels would, therefore, logically have significant influence on certain metabolites, particularly those involved in the biosynthesis of sex hormones and those involved in egg yolk synthesis.

According to Johnson (1970) the presence of lipid in inter-tubular areas of normal testis has been reported as early as 1903 by Loisel. Further, Johnson (1970) has cited that Chamy (1908) has suggested that it could be of nutritional value for the developing spermatozoa. Though lipids are involved in structural formations as well as energy yielding processes, they also provide an important precursor viz.,- cholesterol for the synthesis of gonadal steroids. In vertebrate gonads deplition of cholesterol-positive lipids during breeding phase and the accumulation of the same during non-breeding season characterizes the two phases.

Studies on the relationship between seasons and the lipid composition of the testes of horned-toad lizard

Phrynosoma cornatum (Cavazos and Feagans, 1960), house lizard Hemidactylus flavivirdis (Sanyal and Prasad, 1965), pigeons (Lofts and Marshall, 1959; Hoffmann, 1960; Ambadkar and Kotak, 1976 a and b), starlings (Hilton, 1961) have been reported. Seasonal variation in the ovarian lipids of the crow (Corvus splendens), common myna (Acridotheres tristris) and house sparrow (Passer domesticus) have been reported by Prasad and Guraya (1982). A general survey of literature indicates that majority of studies are biased towards the testes whereas studies on the ovaries are sparse.

As a prerequisite, it was thought desirable to investigate the comparative seasonal variations in the total lipids in gonads and their possible relationship with those of the liver and blood plasma, in two closely related species of birds, Bank myna Acridotheres ginginianus and Brahminy myna Sturnus pagodarum of the Family Sturnidae. The breeding cycles of both of these species almost overlap in time - May early September in the former and late April to late August in the latter species - in around Baroda, India (Longitude 73°13'E and Latitude 22°18'N).

Farner and Follett (1966) have studied cyclic variations in body weight of many avian species. An inverse relationship between monthly variation in

temperature and body weight has been established in the case of Indian house swift by Naik and Naik (1966). Mewaldt and King (1977) have related increase in body weight during winter in white crowned sparrow Zonotrichia leucophrys with accumulation of winter fat reserves. A correlation between body weight and gonads has been established by several workers (Nice, 1937,1946; Dare, 1977; Kotak, 1979; Saxena and Mathur, 1979). During the course of the present study an attempt has been made to look for any possible relation between the changes in the lipid levels of liver, plasma and gonads and those of the body and gonadal weights with particular reference to reproductive cycle.

MATERIAL AND METHODS

The birds used for the present study, Bank myna Acridotheres ginginianus and Brahminy myna Sturnus pagodarum (Family : Sturnidae) were obtained from a local bird supplier. They were sacrificed as early as possible to minimize effects of caging. The body weight of the birds were noted down to the nearest of 1 gm. Blood was collected from jugular vein before sacrificing and kept in the refrigerator for short periods before separating the plasma. All the birds were sacrificed between 8 a.m. to 10 a.m. A sizable .part of the median

lobe of liver and both gonads were dissected out free of adhearing tissue (in latter case), blotted free of tissue fluids and weighed accurately on single pan Mettler balance nearest to 0.1 mg. Part of the liver and part of the gonad (during breeding phase) or the whole gonads (during non-breeding phase) were utilized for extraction of total lipid content. The total lipid content was extracted in the 3:1 (V:V) ether : alcohol mixture by crushing the fresh tissue in a test tube with the help of glass rod and mixed thoroughly with additional 2 ml of ether : alcohol mixture. The test tubes were allowed to stand in the refrigerator till further processing. The test tubes containing lipid samples were then held at 65°±2° C. for 10 minutes in a waterbath. Thereafter the test tubes were centrifuged at 3000 rpm for 5 minutes. Clear supernatant was carefully decanted in the separate graduated test tubes. The process was repeated twice; every time adding 2 ml of fresh ether : alcohol mixture. By this way, approximately 6 ml of supernatant was collected, which was made up to 10 ml by adding additional ether : alcohol mixture. 2 ml of aliquots were taken in preweighed test tubes and evaporated to dryness by keeping the tubes in an air-oven maintained at 60°C. Total lipid content were then calculated gravimetrically. To estimate total lipid in the blood plasma, plasma was separated by centrifuging the whole blood at 3000 rpm for 10 minutes.

To 2 ml of ether : alcohol mixture 0.5 ml of plasma was added, which was allowed to stand for 30 minutes and then the volume was made to 10 ml. The test tubes were centrifuged and clear supernatant was collected in separate tubes. 2 ml of aliquots were used to measure total lipid content gravimetrically.

RESULTS

Seasonal variations in total lipid levels in cases of liver, plasma and gonads are given in Table 1.1 and Fig. 1a and the variations in body weight and that of gonads in Table 1.2 and Fig. 2b.

Lipids — It is obvious from Table 1.1 and Fig. 1a that, the trends of variation in hepatic lipid levels were almost parallel in case of both sexes in the two species. The only interspecific difference being comparative high lipid level during BR in the case of Bank myna. In general, the overall pattern of variation in male birds throughout the year was less obvious in the case of Brahminy myna than that in Bank myna. Plasma lipids exhibited fluctuations corresponding to those observable in hepatic lipids in male birds. On the other hand, the female birds of two species of myna obviously revealed different patterns. Unlike in male birds, the blood plasma lipid levels of

cycle.

TISSUES	MALE Liver*	MALE Plasma**	MALE Testis*	FEMALE Liver*	FEMALE Plasma**	FEMALE Ovary*
Seasons			Bank myna			
PR@	5.936±0.98	1.741±0.2	5.1093±1.15	9.72±0.55	3.56±0.62	24.443±3.63
BR@	14.331±1.94	3.643±0.37	18.981±4.18	15.246±1.46	3.862±0.34	42.584±7.68
PS@	4.013±0.633	1.186±0.025	33.33± 2.13	4.334±0.97	7.111±1.51	36.78 ±6.91
NB@	9.677±0.488	2.467±0.205	59.59± 9.12	9.528±0.731	1.72 ±0.1	28.381±4.8
			Brahminy myna			
PR@	10.533±0.555	3.052±0.203	9.825±0.95	8.509±0.557	2.075±0.091	24.981±3.561
BR@	8.862±0.453	1.993±0.216	6.887±0.492	8.908±0.419	3.383±0.692	18.955±3.287
PS@	6.276±0.259	1.904±0.551	47.932±7.817	6.346±1.117	5.437±1.062	14.038±1.322
NB@	9.351±0.79	1.95 ±0.25	53.669±10.54	9.849±1.304	2.452±0.293	34.89 ±2.311

Values expressed as mean±S.E.

* mg/100 mg fresh tissue weight ** mg/100 ml plasma

@ PR - Pre-breeding Phase, BR - Breeding phase, PS - Post-breeding phase, NB - Non-breeding phase

TOTAL LIPIDS

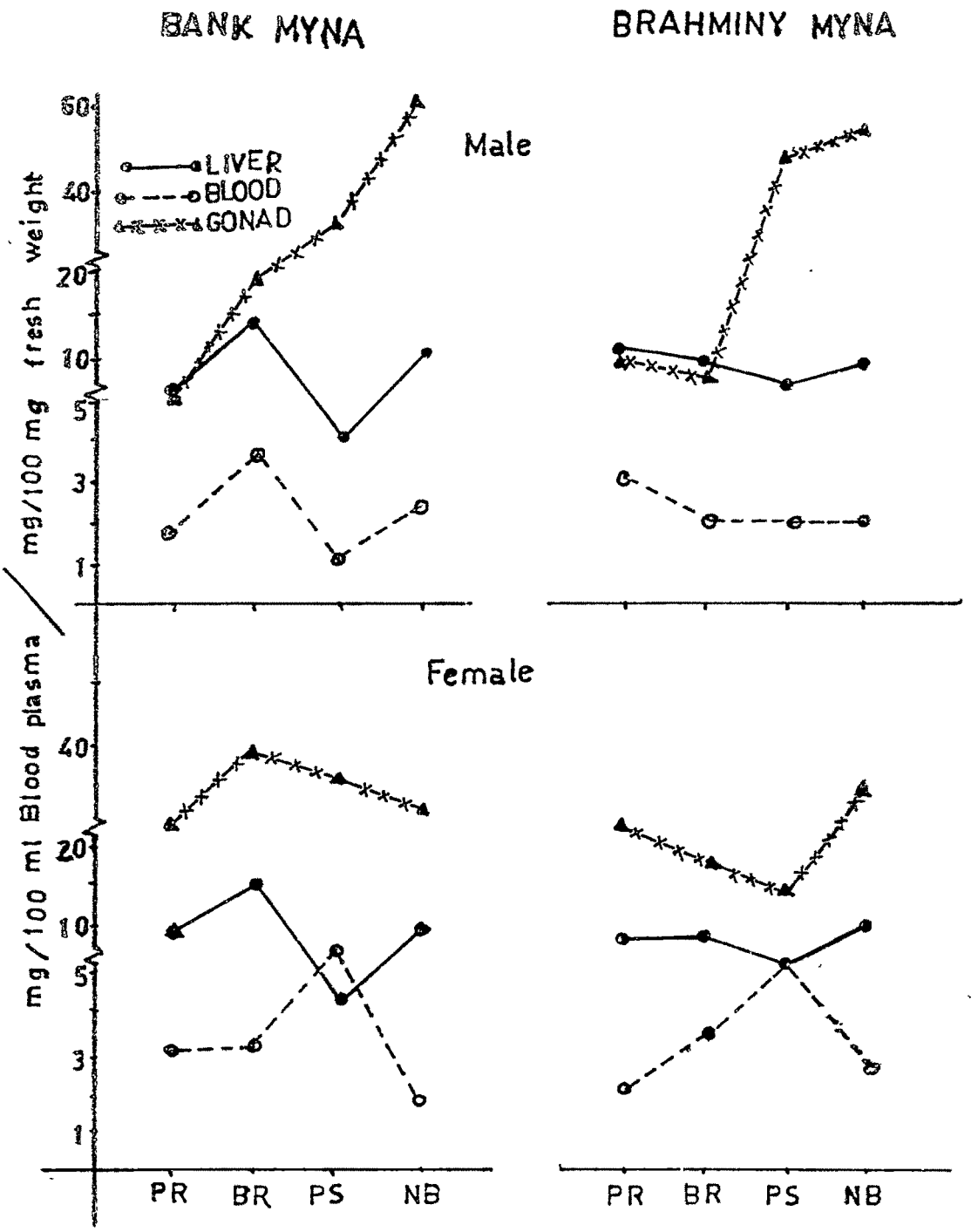

Fig. 1a

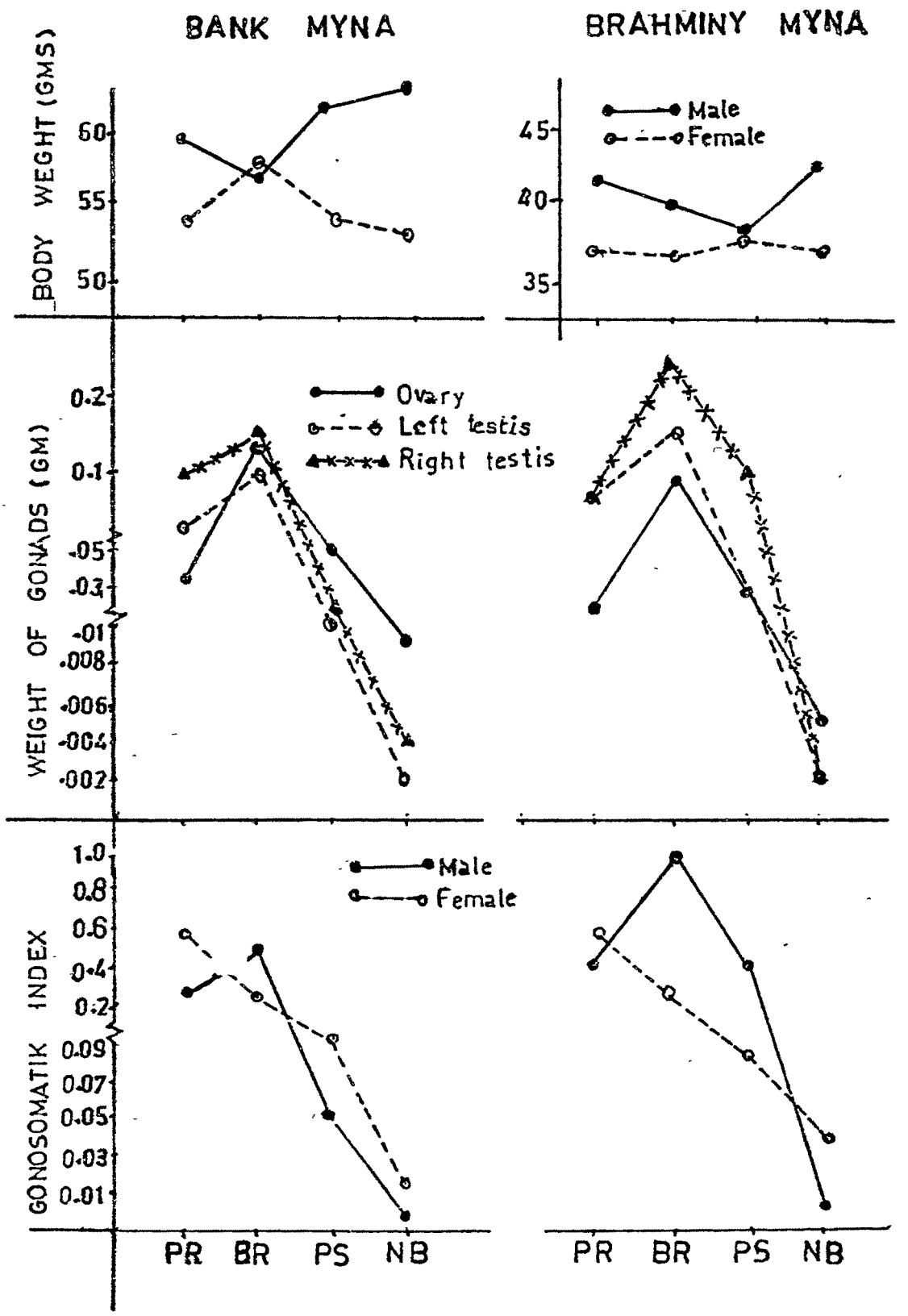
BANK MYNA
BRAHMINY MYNA
BODY WEGHT (GMS)
60
55
50
45
40
35
Male
Female
WEIGHT OF GONADS (GM)
0.2
0.1
.05
.03
.01
.008
.006
.004
.002
Ovary
Left testis
Right testis
GONOSOMATIK INDEX
1.0
0.8
0.6
0.4
0.2
0.09
0.07
0.05
0.03
0.01
Male
Female
PR
BR
PS
NB
PR
BR
PS
NB

Fig 1-b

females of both species exhibited an inverse relationship with those of liver lipids. Secondly, the highest plasma lipid levels were registered during PS and the lowest during NB. Again, the rise during PS and the fall during NB were quantitatively more steep in Bank myna than in Brahminy myna.

Gonads revealed noticeably different patterns of lipid variation as far as both the sexes as well as the species were concerned. Testicular lipids in Bank myna exhibited a steady rise from PR to BR to PS to NB, whereas in Brahminy myna there was a slight decrease from PR to BR but for the rest of phases it was similar to Bank myna. Apparently therefore, the rise from BR to PS in the case of Brahminy myna was comparatively steep. Maximum lipid levels in both the species were recorded during NB.

Ovarian lipid levels were at the minimum during PR in Bank myna and during PS in Brahminy myna. In Bank myna maximum level was attained during BR and thereafter there was gradual reduction through PS to NB. In contrast, ovarian lipid content in Brahminy myna exhibited different pattern. Ovarian lipids were higher during PR and decreased further gradually through BR to PS but there was a sudden increase during NB, which was the highest value recorded for the species.

Body weight — Male birds generally weighed more than female birds almost all throughout the cycle except during BR in Bank myna and PS in Brahminy myna and at these said phases both the sexes of respective species weighed more or less same.

Further, it is evident from Table 1.2 and Fig. 1b that the male and female birds exhibited very different trends of variation in body weights, in both of the species. Body weight of male birds of both the species registered an increase from PS to NB, however, the lowest body weight was recorded in case of Bank myna during BR whereas the minimum body weight was observed during PS in the other species.

Though a noticeable increase in the body weight of female Bank myna only was observable from PR to BR, otherwise the body weight in female birds of both the species did not exhibit any significant variations throughout the remaining phases of the breeding cycle. This amounts to say that the female birds of Brahminy myna did not show appreciable variation during the various phases of reproductive cycle. Under such circumstances the values of gonosomatic indices become obviously better indicators vis a vis lipid contents of liver, blood plasma and gonads.

Gonads — Gonads of both sexes weighed highest during BR and lowest during NB in both the species. As compared to Bank myna the decrease in testicular weight was found to be less steep in case of Brahminy myna.

There was an increase in gonosomatic indices (GSI) of male birds of both species from PR to BR and a steep fall from BR to PS to NB. GSI of male Brahminy myna was almost double than that of Bank myna, except during NB, when it was found to show almost similar values.

In general, GSI was noticed to decrease gradually from PR through BR, PS and NB in case of female birds in both species. This means that the female birds did not show species-specific differences in GSI during the phases of reproductive cycle except at NB when only in Brahminy myna females the GSI value was slightly higher. In female birds GSI decreased gradually from PR to BR to PS to NB.

DISCUSSION

In general, the male birds were heavier than female birds. However, only during BR in Bank myna and PS in Brahminy myna the differences between body weights of male and female birds were negligible. The actual range of body weight of Bank myna was from 54 to 68 gms in male birds (minimum and maximum mean values being 56.8 and

62.4 gm) and that of female birds was 52 to 62 gms (minimum and maximum mean values being 53.0 and 58.2 gm). Similar ranges in Brahminy myna were :- male birds - 37 to 45 gms (mean 38.0 and 42.6 gms) and female birds - 32 to 42 gms (mean 38.0 and 37.5 gms). Male birds weighed maximum during NB in both species except for the fact that only during BR the females of Bank myna were found to be slightly heavier than males. As against this the female birds of Brahminy myna registered minimum body weight during BR, however, the variation in the body weight in case of female Brahminy myna during different phases was non-significant. It is necessary to note here that, against average mean body weight ranges mentioned so far, there was a sudden increase just prior to oviposition in body weight of female birds of both species upto 71 gms in Bank myna and 47 gms in case of Brahminy myna. However, individual variations with regard to body weight were met with, occasionally.

The present observations on body weights find support in earlier reports of Wexelsen (1937) and Kotak (1979) on pigeons and those of Chaturvedi and Thapliyal (1980) on Common myna, who have also noted that generally male birds are heavier than the female birds. Contrary to this, female birds are known to be heavier in Chimney swift Chaetusta pelagica (Johnston, 1958) and Great tit Parus

major (Hafton, 1976). Though Saxena and Saxena (1977) working on black-breasted rain quail, reported that the male birds are smaller than female birds, Saxena and Thapliyal (1977) did not find consistent sex differences with respect to the body weight. No strikingly significant differences in body weights of male and female birds were seen in case of the house swift Apus affinis (Naik and Naik, 1965) and the Indian house crow Corvus splendens (Chauhan, 1979). Accumulation of winter fat reserves have been reported in case of birds (Nice, 1937, 46; Mewaldt and King, 1977; Saxena and Mathur, 1979). Naik and Naik (1965 a) have suggested that the increase in body weight during winter to be inversely related to environmental temperature and directly to humidity in the case of the house swift Apus affinis. Increase in body weight during post-nuptial moults have been known to occur in both sexes of white crowned sparrow Zonotrichia leucophrys (Mewaldt and King, 1977) and pigeon Columba livia (Kotak, 1979). During the course of the present work, it was observed that only the male birds gained in body weight in both the species of birds during NB, that is from December to February (colder months of the year). Thus, male birds of the two species of myna did show an inverse relationship with ambient temperature. On the other hand, female Bank myna exhibited a direct relation to falling ambient temperature, whereas those of Brahminy

myna did not exhibit any such relation nor was there any noticeable variation in their body weights throughout the reproductive cycle. This indicated that in both species male and female birds have remarkably different patterns of variations as far as the body weights are concerned. On the other hand, if one considers the variations in gonadal weights in both sexes of the two species of birds, then almost congruent patterns of variation could be noticed. It is therefore, suggested that GSI (Table 1.2 and Fig. 1b) values are better variables for interpreting the weight variations, rather than considering body weights or gonadal weights per se, at least in the present context.

Further, if one takes into account the diurenal time budget studies of the behaviour of male and female birds of Bank myna, as reported by Khera and Kalsi (1986), a few more points emerge. During the days of incubation (PS) the males spend maximum time in foraging and resting thereby leading to gain in body weight, whereas the females spend maximum time in incubating activity and very little on foraging thereby leading to less feeding and thence to decrease in body weight. Incubating activity, though of resting type, nevertheless is highly energy consuming as necessary loss of bodily heat occurs hence, the female birds probably loose body weight during post breeding phase as noted in the present report. The author would like

to add that this loss of body weight then may not be merely due to comparatively cooler ambient temperature alone but more due to expenditure of energy for incubation, since Bank mynas breed in hole-nests where the falling embient temperature may not be such a significant factor.

Though in the case of Brahminy myna, similar diurnal time budget data are not available, author's own field observations indicated that in this species both sexes of birds take almost equal parts in the incubation activity, females do get free time to go on foraging than their counterpart of other species of myna studied. Hence, decrease in body weight in the case of female Brahminy myna is almost not noticeable.

The other relevant factor taken into consideration during the present work was concerned with variations in the total lipid contents of gonads, liver and the blood plasma. The idea was to find out if there could be any meaningful relationship between these parameters and the reproductive cycles on comparative basis between the two species of myna viz., Acridotheres ginginianus the Bank myna and Sturnus pagodarum the Brahminy myna.

From the Table 1.1 and Fig. 1a it is obvious that there are remarkable species - as well as sex-specific differences as far as seasonal changes in the levels of

total lipids of gonads, liver and blood plasma are concerned. For the sake of convenience, the discussion would follow the sex-specific alteration in one species at a time and then the inter-specific differences would be dealt with.

Most of the seasonally breeding vertebrates are known to show a seasonal lipid cycle in the form of decrease during active spermatogenesis and steroidogenesis and its increase during non-breeding phase (Johnson, 1970; Lofts and Lam, 1973; Skinner et al., 1973; Ambadkar and Kotak, 1976 b; Ambadkar and Chauhan, 1979 a; McPherson and Marion, 1982; Bechan Lal et al., 1987; Patel and Ramachandran, 1987; Pistole, 1989). Accumulation of lipid in the testes of geese between the two breeding seasons was reported by Parhon and Parhon, as early as 1922. Moore (1924) suggested the storage of lipid in Sertoli cells and its unavailability for use in the absence of spermatogenesis. Accumulation of cholesterol positive lipids in ovaries of housecrow C. splenders during regessive phase has been reported (Ambadkar and Chauhan, 1979 b).

With reference to the Bank myna, it can be seen that gonadal and blood plasma lipid levels exhibit distinct sex-specific differences of variation patterns, whereas that of hepatic levels are mostly similar. This means the liver lipid synthesis shows an increase during the transition

from PR to BR. During that period the male gonads triple the lipid value but the female gonads double. This means that the liver may be releasing more lipids into circulating blood to be taken up by the gonads. However, the rise in plasma level is much marked in male than in females. If the assumption about hepatic lipid mobilization is true (Ranney and Chaikoff, 1951; Ranney et al., 1951; Lorenz, 1954; Heald and McLachan, 1964; Husbands and Brown, 1965), then the variation in plasma level, in all probability indicated sustained but slow uptake by testes as compared to episodic but quick uptake by the ovary. Further, it could be seen that the testes continue to accumulate lipids post-spermatogenically whereas the ovary loses on account of deposition in yolk and subsequent oviposition (and further drastic regression in ovarian volume).

In the case of Brahminy myna, as opposed to the above account, the patterns of lipid variations in gonads, liver as well as plasma depicted totally different profiles in males and females, though only the fluctuations in hepatic lipid levels were minimum in both sexes. However, the relationships with the other two parameters in two sexes were at variance. From PR to BR the ovary as well as testes registered decrease but plasma level in females increased and that in males decreased. The latter parameter increased further in female birds from BR to PS and decreased from PS to NB, but in male birds remained

low throughout. There was a steep rise in testicular lipids from BR to PS (that is post spermatogenic lipid accumulation) with a further slight rise from PS to NB.

In the case of Brahminy myna, ovarian lipid loss due to oviposition was obvious from BR to PS, however, lipid accumulation due to regression was apparent from PS to NB. Probably low hepatic and ovarian lipid levels occurring when the plasma profile was highest, in the whole of cycle, is indicative of enough foraging activity on the part of the female birds for self nurture as well as that of the fledglings during that phase. This also got reflected in increased lipid accumulation in the ovary. It seems from personal casual observations that males of this species probably do not play any considerable role in feeding the fledgings.

Coming to the species-specific differences, the following points may be mentioned :- (i) the hepatic lipid levels in the two sexes of both species depict similar profiles but bear very different relationships with other two parameters, (ii) though the testicular lipids show post spermatogenic lipid accumulation in both the species, the ovarian lipid level was strangely lowered during NB in case of Bank myna as opposed a distinct high level in Brahminy myna (the highest of the cycle). Plasma lipid profile varied differently as far as

the sex within the species as well as between the two species. No definite pattern was discernible in this parameter.

In conclusion, it could be said that the two species of myna under study, though exhibiting a time-overlap in breeding season, have their own patterns of variation in body weight, gonadal weight and total lipid contents of gonads, liver and blood plasma, each suited perhaps for its own mode of reproductive cycle. More work is certainly necessary to arrive at any definite inferences regarding the observations reported here.