INTRODUCTION

The monogeneans are usually ectoparasitic in fishes and amphibians. Exceptional occurrence were reported in aquatic mammals, in the eye of a hippopotamus in Uganda (Thurston and Laws, 1965), crustaceans and cephalopods. Endoparasitic monogeneans include species of Enterogyrus Paperna, 1963 in intestine of fish (Paperna, 1963; Gussev and Fernando, 1973), Dictyocotyle Nybelin, 1941 species in coelom of Raja linitia, Acolpenteron ureterocetes Fischthal et Allison, 1940 in ureter of a fish, Polystoma integerrimum (Froelich, 1791) Rudolphi, 1808 in the bladder of amphibians (Cheng, 1986) and dactylogyrid in the ovipositor of Amur (Yukhimenkov and Danilov, 1987). Ectoparasitic monogeneans usually attach to gills, scales and fins of fishes. In many cases these parasites show preference to a particular gill or gills, eg. Diclidophora merlangi (Kuhn in Nordmann, 1832) Kroyer, 1838 attaches more frequently to the first gill of whiting and D. iuscae (Ben et Hesse, 1864) Price, 1943 favours the first and the second gills of trout. Llewellyn (1956) observed that while the posterior end of the parasite is located close to the gill arch, the anterior end is close to the distal end of the primary lamellae. In all instances the mouth of the parasite faces downwards.
Beneden (1858) distinguished trematodes into "Monogeneses" and "Digeneses" on the basis of a single generation of the life cycle in the former and a sexual generation alternating with asexual generation in the latter. Subsequently, the names were latinized by Carus (1863) and thus they came to be known as "Monogenea" and "Digenaea". There was general agreement that monogeneans had monogenetic life cycle and digeneans had digenetic life cycle. Interestingly, aspidogastreids, now identified as a separate group, Aspidogastrea and admittedly close to digenea, have monogenetic life cycle and the monogenean viviparous gyrodactylids, have more than one asexual generation produced through polyembryony. The difference between monogenea and digenea, therefore, perhaps rests on the absence of an intermediate host in the life cycle of the former. Even this becomes suspect in view of Bychowsky and Nagibina’s (1967) report that in Pricea multae Chauhan, 1945 and Gotocotyla species Ishii, 1936, which live in predatory fish host, Scomberomorus commersonii and Sawara niphonica, a nonspecific intermediate host facilitates invasion of the specific definitive host.

Curiously, the parasitic phase in monogenea is the mature phase, the rest of the life cycle is more or less free (except in gyrodactylidae). Most monogeneans, like digeneans, assemble operculate eggs with rigid shells made up of tanned proteins and these eggs undergo embryonic
development outside the host and on hatching liberate a
ciliated free swimming larva called oncomiracidia. They are
essentially hooked larvae. There are two kinds of
oncomiracidia, a nonciliated one for reinfecting the same
host and a free swimming ciliated one for seeking out a new
host. Bychowsky (1957) described two phases of activity of
ciliated larvae, (i) a free swimming phase in search of a
host, and (ii) a creeping or gliding phase over the surface
of its host. In the first phase the movement is by epidermal
cilia; muscular movements are involved during the second
phase. Most oncomiracidia are covered externally with
ciliated epidermis. Ciliated epidermal cells are distributed
in three zones, anterior, middle and posterior. The pattern
has been well documented by Bychowsky (1957) in Polystoma
integrivirum. In the anterior zone there is a single apical
cell and a horse-shoe shaped band of 24 cells with the open
end directed dorsally. The middle zone of 18 cells is again
horse-shoe shaped but the open end is directed ventrally.
The posterior zone has a horse-shoe of 12 cells covering the
dorsal surface of the haptor, the ventral surface being
devoid of cilia. This arrangement of epidermal cells is
prevalent also among most monopisthocotyleans, their number
ranging 45 or more. In diclidophoridians, however, an
entirely different pattern exists and the number of
epidermal cell is never more than 30. A most distinctive
feature of oncomiracidia is their haptor and, except in
Udonellidae and Microbothridae, the haptor is always provided with skeletal structures in the form of hooks and sometimes bars. The marginal hooks are remarkably constant, with a proximal straight handle, distal curved blade, ending in a sharp point, a guard and a domus. The number of marginal hooks varies between 10 to 16. They are arranged equidistantly and often a large interval separates the two anterior most ones to give the haptor a bilateral symmetry. There has been quite some difference of opinion in the nomenclature of these hooks. There are at least 5 different methods of numbering of marginal hooks (Kulwiec, 1927; Lambert, 1975; Llewellyn, 1957, '63; Mizelle, 1936, '37; Mueller, 1936). Gussev (1979) suggested that it would be worthwhile returning and sticking to Kulwiec's (1927) system. This would remove so much of confusion. In Tetraonchids, Entobdellids and Acanthobdellids, two hooks, exactly similar to marginals, lie in the middle of the haptor. It is possible that either the first or the last pair have migrated to the centre. Exceptionally, the centrally placed hooks may grow into hamuli and even be increased from one to two pairs. They may be accompanied with accessory sclerites in the form of transverse bars.

Post oncomiracidial development of monogenea includes three main phases, (i) growth, (ii) development of genitalia, and (iii) the development of definitive adhesive apparatus. This latter phase may meet with one of the 3 fates:
(I), it may not undergo any further development at all;  
(II), it may grow and preserve its general discoidal shape but acquire 1 or 2 pairs of hamuli, sometimes accompanied with one or two bars; and  
(III), it may grow and acquire a completely new kind of unarmed suckers.

Based on haptoral skeletal structures Janicki (1920) advocated that the monogenean oncomiracidium resembles more a decacanth lycophore of gyrocotylideans and amphillinideans and coracidium of cestodes than the miracidium of digenean or larvae of aspidogastrids. He was the first to propose that monogeneans be removed from digeneans and be associated with gyrocotylideans. He raised a new group Cercomerophora to include monogenea, gyrocotylideans, amphillinideans and cestodes. Fuhrmann (1928), Baer and Euzet (1961) rejected this. Bychowsky (1937, '57) resuscitated this idea and removed Monogenea from Trematoda and included it with Gyrocotylidea, Cestodaria and Cestoda in a new superclass Cercomeromorphae. Llewellyn (1965) lent strong support. Both Bychowsky (1957) and Llewellyn (1965) envisaged the origin of monogenea in broadly similar ways, i.e., the adaptation of rhabdocoel turbellarians to parasitism on early vertebrates, followed by the appearance of attachment disc or haptor of udonellid type; hook development subsequently in the disc improving attachment to more active fishes. Llewellyn, however, was in total disagreement with
Bychowsky in respect of evolution within monogenea. While
Bychowsky (1957) considered the marginal hooks to be the
first organs of attachment, Llewellyn (1970) thought the
suckers to be the first organs of attachment. This has
brought about an entirely different approach in Llewellyn's
scheme of evolution and classification. Gussev (1978 a)
defended Bychowsky's approach as more rational. Both
Bychowsky and Llewellyn, however, agree in that the
evolution of monogenea was based on the changes in their
haptors and that the pattern and number of hooks, specially
in their larvae, is an important systematic characteristic
and that the ontogenic evidence is the main criteria in
setting up of the classification of the group. Malmberg
(1974), however, looked to the form of excretory system and
Lambert (1979) to the pattern of argyrophilic structures of
the larvae as better clues to the ancestry because
excretory, locomotory and sensory systems were less likely
to be affected by parasitism than were attachment organs.
Both, Llewellyn (1970) and Lambert (1979) recognized 5 major
groups of monogenea, viz., dactylogyrideans, capsalideans,
monocotylids, gyroactylids and polyopisthocotyleans but
interpreted their relationships very differently. Stunkard
(1963, '75) strongly opposed the idea of derivation of
cestodes from monogenetic ancestors. He held that the only
similarity between oncomiracidium and oncosphere is that
both are hook bearing larvae and there the similarity ends.
In the oncomiracidium the hooks are posterior, 10 to 16 in number and function for more secure attachment to vertebrate host; in the oncosphere the hooks are anterior, 6 in number and serve not for attachment but for violent progression and, following metamorphosis, shrivel and disintegrate. To derive cestodes from monogenea it is necessary to provide for introduction of an intermediate host and alternation of generations, metamorphosis and transformation of oncosphere, the reversal of anterior and posterior axes in development and strobilization and duplication of reproductive organs. The monogenetic trematodes are mainly ectoparasites of fishes, cestodes are endoparasites of arthropods as well as vertebrates. The former are simple in morphology and life history, the latter highly specialized parasites known (Baer, 1951). He advocated restoration of Pectobothridia and Malacobothridia, the terms initially proposed by Burmeister (1856) and was later followed by Schaperclaus (1991). Be that as it may, the present author finds substantial merit in Cameron’s (1964) suggestion that the monogeneans, digeneans, cestodaria and cestoda perhaps all arose from the ancestral rhabdocoele turbellaria, each in its way and none being the forerunner of the others. Monogeneans primarily became associated with fish hosts and evolved with them, the others arose as endoparasites of invertebrate hosts and, only later, with ingestion of these by vertebrates, they colonized the latter.
Oncomiracidia have led to yet another characteristic of monogeneans, namely, their exceptionally narrow specificity in the mature phase. Occasionally, they do get attached to unusual hosts but their maturation occurred only in the specific host. In digeneans, cestodes and even nematodes, on the other hand, the larvae are more specific. Llewellyn (1982) distinguished two kinds of specificity, namely, phylogenetic specificity, when related parasites occur in related hosts, and ecological specificity, when related parasites occur on unrelated hosts, sharing a common habitat.

Euzet and Raibaut (1960) presented the first evidence of chemical stimulation of hatching in a polyopisthocotylean monogenea. More detailed understanding of role of hatching factors was provided by Kearn (1967, '73, '74 a, '75, '82, '88). In *Entobdella soleae*, (Beneden and Hesse, 1863) Johnston, 1929, a parasite of *Solea solea*, he observed a circadian rhythm in the first four hours of sunrise. In *E. hippoglossi* (Muller, 1776) Johnston, 1856, a parasite of *Hippoglossus hippoglossus*, on the other hand, rhythmic hatching was noticed two hours after sunset. In *Dictyocotyle coelica* Nybelin, 1941, a parasite of *Raja naevus*, he found hatching was continuous throughout light and dark without any daily rhythm. This rhythmicity is clearly synchronized with host habit. Further, while the host skin mucus caused
immediate hatching in Acanthocotyle lobianchi Monticelli, 1888, and accelerated hatching in E. solea, it did not have any effect on E. hippoglossi and D. coeliaca. Further, in E. solea Kearn (1981) reported that the ciliated larvae are infective immediately after hatching and actively locate Solea solea resting in the vicinity. In A. lobianchi, on the other hand, the larvae are nonciliated and the infection occurs with the chance contact of the host. Similar observations have been noticed in a skin parasite Leptocotyle minor Monticelli, 1888, and a gill parasite Hexabothrium appendiculatum (Kuhn, 1829) Nordmann, 1840, both from dog fish Scyllorhinus canicula. In these cases the larvae have ciliation and there is a free swimming phase including a photopositive and a photonegative period. Host finding occurred during the latter period.

Kearn (1974 b), Kearn and Macdonald (1976) thought chemical factors in the mucous of sole and rays as small and stable molecules and implicated urea, ammonium chloride, and arginine in the hatching of E. soleae. In A. lobianchi it was said to be only urea. Kearn and Macdonald (1976) estimated that the levels of urea in ray skin mucous were relatively high providing a strong hatching stimulus in A. lobianchi. Kearn (1986), however, concluded that when a chemical cue was involved, the hatching stimulus was non-specific. In host finding, on the other hand, the chemical cues have to be specific. What exactly is the factor leading
to host finding and determining host specificity still remains an enigma. These chemical cues have been called as 'telorgons' by Kirshenblat (1968) in metazoa. Gussev (1978 b) used the term 'epagons'. He held the view that it was extremely important to revive studies on nature of specificity and on its biochemical basis. Gussev, further, observed that the simplicity of life cycle is also very significant in the development of their narrow specificity. Among parasites with complex life cycles narrow specificity is less likely. The monogeneans are distinguished by the greatest species variety of all parasites of freshwater fish. With rare exception, they are present, frequently in large number, in each specimen and species of Cyprinidae and Siluridae (Gussev, 1978 b), often more than one species, sometimes as many as 10 to 13 species. The overwhelming majority of Indian monogenea are found on a single species of fish (monohostal). The same thing can be said of most representatives from other parts (Bychowsky, 1933, '57; Bychowsky and Nagibina, 1959; Glaser, 1965; Gussev, 1955; Ergens and Lom, 1970; Khalil, 1971 a; Paperna, 1973). A small number of species, however, infest several species of fish. In such cases the hosts are clearly genetically related. Bychowsky (1933, '57) formulated a rule that representatives of the genus Dactylogyrus Diesing, 1850 were found either on the same species or on several which belong to one or more closely related genera of fish. He opined
that this rule has general application in monogeneans, e.g., incidence of *Dactylogyrus* and the entire subfamily *Dactylogyrinidae* characteristically in *Cyprinidae* and to a lesser extent in *Catastomidae*; species of *Cornudiscoides Kulkarni, 1969* and *Bifurcohaptor Jain, 1958* in *Mystus* and, as a matter of fact, the entire *Ancylodiscoidinae* in *Siluriformes; Quadriacanthus Paperna, 1961* in *Claridae; Schilbetrema Paperna et Thurston, 1958* in African *Schilbeidae; Cichlidoogyrus Paperna, 1960* in *Cichlidae* and *Annulotrema Paperna et Thurston, 1969* in *Characidae*. This very narrow specificity has led to a situation that in one species of fish, say, *Wallago attu*, species of *Ancylodiscoides Yamaguti, 1937, Parancylodiscoides Achmerow, 1964* (*Silurodiscoides Gussev, 1976*), *Bychowskyella Achmerow, 1952* and *Mizelleus Jain, 1957* have all been reported. Likewise, in *Clarias batrachus*, species of *Bychowskyella* and *Quadriacanthus* occur and, further, *M. vittatus* is found to harbour species of *Silurodiscoides, Cornudiscoides* and *Bifurcohaptor*. This means that the parallelism in host parasite evolution can not be absolutized. A factor in the speciation of monogeneans is the topologic differentiation of populations. *Dactylogyroides tripathii (Tripathi, 1959; Yamaguti, 1963)* *Gussev, 1976* is found from the middle to distal ends of primary lamellae of gills of *Puntius stigma* and *D. longicirrus (Tripathi, 1959)* *Gussev, 1976* occurs from middle to the base of gills. *Paperna (1978)* observed that
while Cichlidogyrus sclerosus Paperna, 1978 occurred on the proximal part of the gills, C. tilapiae Paperna, 1960, C. tiberianus Paperna, 1960 and C. longicirrus Paperna, 1978 inhabit the distal third of the gills. Ecologic geographic differentiation of populations provided yet another factor in speciation of Amur fauna (Gussev, 1955). Ancryocephalus (S.I.) esomi Gussev, 1963 and A. (S.I.) chakrabartii Gussev, 1976 are undoubtedly genetically close. However, the former is found in Sri Lanka and the latter is found in India. Examples of this kind can be many. Precisely these factors have been responsible for the restriction of the Indian monogenea to species of Gyrodactylidae, Dactylogyridae, Ancryocephalidae, Discocotylidae in catfishes.

Gussev (1978 b), in an analysis of freshwater monogeneans in a global scale, has identified six main zoogeographic faunae, namely, (1) Indian; (2) African (Ethopian); (3) Far-Eastern or Amur-Chinese; (4) Palearctic; (5) Sonoran (neoArctic) and (6) South American (neotropical).

Gussev (1978 b) characterized the Indian fauna (168 species distributed in 23 genera) with (i) great variety of Dactylogyridae (77 species spread over 4 genera) and Ancylodiscoidinae (48 species in 8 genera) and occurrence of Ancryocephalinae (30 species in 7 genera); (ii) presence of Diplozoon Nordmann, 1832 and a unique genus Neodiplozoon
Tripathi, 1960 and absence of any other Discocotylididae and Tetraonchidae. Notable Indian work on monogenean fauna relate to Baugh (1957), Chauhan (1953 a, b), Dayal (1941), Fotedar et al. (1970), Gussev (1976), Jain (1952 a,b, '55, '57 a,b,c, '58, '59 a,b,c,d, '60, '61 a,b), Kaw (1950), Kulkarni (1969 a,b,c, '70, '71), Pandey (1973), Price (1938 a), Srivastava (1975), Swarup (1978, 81), Thapar (1948) and Tripathi (1958, '75).

The African fauna (150 species in 23 genera) is characterized with (i) great variety of Ancyrocephalinae (68 species in 11 genera); occurrence of Dactylogyridae (45 species in 4 genera) and Ancylodiscoidinae (12 species in 4 genera); (ii) presence of large number of species of Cichlidogyrus; (iii) presence of some 6 species of a unique genus Macrogyrodactylus Malmberg, 1956; and (iv) some species of Diplozoon. Khalil (1971 a& b), Manter (1963, '67), Paperna (1969 a & b, '73, '78, '79), Paperna and Thurston (1968), Price (1968 a), Price and Pike (1969) and Price et al. (1969) have all contributed to the studies in this region.

The far-Eastern or Amur Chinese fauna (268 species in 15 genera) is characterized with (i) richness of Dactylogyrus (147 species) and occurrence of Ancylodiscoidinae (28 species in 3 genera) and Ancyrocephalinae (16 species in 3-4 genera); (ii) presence
of Diplozoon. Prominent work in this region relate to Achmerow (1952, '64), Berg (1909, '49), Bychowsky (1957), Gussev (1953, '55, '64), Gussev and Strelkov (1960), Strelkov and Shul'man (1964, '71) and Yamaguti (1963, '68).

The Paleartic fauna (315 species in 19 genera) is characterized with (i) richness of species of Dactylogyrus (126 species) and Ancylodiscoidinae (104 species) and occurrence of Ancryocephalinae (12 species in 4 genera); and (ii) presence of several species of Diplozoon and Octomacrum Mueller, 1934. Notable contributions in this region relate to Bauer and Gussev (1969), Bychowsky (1933, '37), Bychowsky and Nagibina (1959, '69) and Gussev (1966).

The sonoran fauna (378 species in 24 genera) is characterized with (i) richness of Dactylogyridae (137 species) and absence of Ancylodiscoidinae; (ii) exceptional richness of Ancryocephalinae (129 species) and absence of Diplozoon but presence of Discocotyle and Octomacrum. Curiously, species of Ancryocephalidae have no trace of anchors. Notable contributions in this region relate to Hargis (1953 a,b, '55), Hoffman (1967), Mizelle (1938 a,b, '62, '63), Mizelle and Hughes (1938), Mizelle and Kritsky (1967 a,b,c), Mizelle and Mcdougal (1970), Mueller (1935,'37, '38), Price (1967 a), Price and Mizelle (1964) and Rogers (1967).
Neotropical fauna (67 species) is characterized with (i) Ancylodiscoidinae with unilateral anchors; (ii) Ancyrocephalinae with reduced anchors and one dorsal bar and, Gyrodactylidae with no anchors. It is possible that there are no species of Dactylogyrus since there are no Cypriniformes. Notable contributions in this region relate to Manter (1963, '67), Mizelle et al. (1968) and Price (1938 b, '67 b, '68 a).

Comparing these six, Gussev (1978 b) grouped Indian and African faunae into one; Paleartic and Amur Chinese into another; Sonoran fauna into a third and the neotropical fauna in the fourth group in terms of composition, morphology and number of species.

Chubb (1977) in an extensive review has discussed the seasonal occurrence of monogeneans in freshwater fishes. Notable contributions in this field of study relate to Bauer (1959 a), Bauer and Nikolskaya (1957), Bauer et al (1959 a), Campbell (1974), Crane and Mizelle (1968), Izyumova (1958 a, b, '60, '64), Kashkovski (1967), Komarova (1964), Malmberg (1970), Molnar (1968, '71 a,b,c, '72), Musselius (1968), Prost (1963), Rautskis (1970 a,b), Rawson and Rogers (1972 a,b) and Wootten (1974). In his review Chubb (1977) concluded that temperature of water is the primary factor in an explanation of seasonal incidence, intensity and reproduction of Dactylogyrids and Gyrodactylids. All other
factors are secondary to temperature. Shul'man (1987) has incriminated another factor, i.e., lengthening of day light (during March to May) in sharp increase of Gyrodactylids and shortening of day light (in November) in the population reaching minimum. Temperature above $30^\circ C$ and below $10^\circ C$ are not congenial to these worms and their populations decline to a minimum. Overwintering, at egg stage, follows water temperature below $8^\circ C$ in *D. vastator* Nybelin, 1924 (*Nordquist, 1925; Nybelin, 1925; Wunder, 1929*). Chubb (1977) concluded that there is a great variation in pattern of occurrence; some species show minimal changes of incidence and intensity during the year, others have minimal changes of incidence but considerable changes of intensity, while yet others have marked changes of both, often with periods of absence from the host. It is impossible to generalize, so each species would have to be considered separately. Paperna (1964 a) has discussed yet another aspect of competitive exclusion of *Dactylogyrus extensus* Mueller et Van Cleave, 1932 by *D. vastator* on the gills of a reared carp in concurrent infection. As luck would have it, there is not a single species of monogenea whose dynamics or population biology is known from India.

Smyth and Halton (1983) have discussed at length physiology of monogeneans. They distinguished these into surface epithelial tissue feeder (*monopisthocotylea*) and blood feeders (*polyopisthocotylea*). Unlike digeneans,
digestion in monogenea is largely said to be intracellular and appears to involve all the elements of lysosomal system. Based largely on histochemical study, proteases, carboxylic esterases, thiamine pyrophosphatase, alkaline phosphatase (acid phosphatase activity not found in monogenea), have all been said to be involved in the digestion in monogenea. As ectoparasites, most monogenea have direct access to oxygen. Polyopisthocotyleans may also ingest oxygen in food. Oculotrema Stunkard, 1924 (Polystomatinae), from the eye of hippopotamus is said to have endogenous hemoglobin, which can have respiratory significance as an oxygen store and can facilitate parasite to exist in a region of low oxygen pressure, such as under the eyelid of the host. Smyth and Halton (1983) held that studies on metabolism of monogenean is practically non-existent. Stray studies reveal that the oxygen uptake is inhibited by low concentrations of cyanide and markedly reduced by rotenone and by antimycin-A in Diclidophora merlangi. All these suggest an aerobic respiratory chain. The ectoparasitic monogenea store very little glycogen, while the endoparasitic genera (Polystoma) contain high glycogen content (like digenea). This may perhaps be related to their modes of life. It is also possible that low glycogen reserves are related with low fecundity and a predominantly aerobic respiration. All these would need to be affirmed experimentally. In lipid metabolism, the lipid content is said to fall rapidly during
starvation of *Diclidophora* Diesing, 1850. Most of the lipid in *Diclidophora* are phospholipids, triglycerides and cholesterol esters. It is unlikely that monogenea synthesize fatty acids and sterols and perhaps they get these with the food.

Amino acid composition of protein is known in very few monogeneans. They can undoubtedly ingest and degrade large amounts of proteins and proteolytic enzymes have been reported as involved in protein degradation. There is a lot needed to be done in this field. Arme and Whyte (1975) reported proline as high as 70% of the total free amino acid pool in *D. merlangi*. They rationally analyzed the significance of this very high level of proline in *D. merlangi*. Whether this could be due to high proline level in diet or high proline level in parasite protein; whether proline has an osmoregulatory role and whether there is a specific proline involvement in metabolism, perhaps as energy source or excretory product. On the basis of their experimental data, Arme and Whyte concluded that the high level of proline did not conform to any of these possible roles. In another study Arme (1977) reported very high levels of proline in free pool of amino acids in *E. hippoclossi* and *Dictyocotyle*, amongst monopisthocotyleans, and *D. merlangi* and *D. denticulata* Olsson, 1876 amongst the polyopisthocotyleans. The significance of this very high
level of proline in all these monogeneans thus remains an enigma.

Although nothing is known about the reproductive physiology and maturation of these worms, Smyth and Halton (1983) conjectured, on the basis of the correlation between the life cycle of Polystoma Zeder, 1800 and its frog host, that reproductive development in Polystomatids is controlled by the hormonal activity of the frog. Further, in many monogeneans (Dactylogyrus, Diplozoon) there is a strong seasonal variation in the reproductive capability. The gonads begin to function in spring, reaching a peak in summer; regression occurring with the onset of winter. The physiological basis of synchronization is again an enigma, may be that, it is controlled by temperature and day length. The egg shell production and embryonation are both affected by temperature, increasing with rise in temperature and retarding with drop in temperature. Circadian rhythm is reported in many. Oxygen tension can also be important. Osmotic stimulus may also be relevant. As discussed earlier, circadian rhythm, increasing day length and ‘chemical cues’ may all together or singly be responsible for triggering hatching.

Most monogeneans are skin and gill parasites. In a general discussion on pathophysiology and systemic pathology of teleosts, Roberts (1978) has elucidated several
manifestations, like oedematous separation of respiratory epithelium of primary and secondary lamellae and necrosis of lamellar epithelial cells causing severe, often lethal, respiratory and osmoregulatory distress.

Bauer et al. (1977), in their monograph on Ichthyopathology, have discussed 'Dactylogyrosis' and 'Gyrodactylosis' of freshwater fishes in USSR. Dactylogyrus vastator infests gills of carp and hybrid variety of carps and is found on the ends of the gill lobes. It frequently infests carps by causing severe epizootics. In some pond forms of Ukraine, death of carp fry was said to be as high as 100% in 1950. The diseased fish become disquiet and collect in masses at the influx of water. The gills of diseased fish become pale, sometimes mosaic, with alternating sections of red and pale pink colour and abundantly covered with mucous. In places, where Dactylogyrus are found attached, the epithelium proliferates, forming long strands. The location and structure of the capillaries is disrupted, obstructing gas metabolism. The damage to gill apparatus results in impairment of respiratory function and the haematological picture of the diseased fish show increased neutrophils, decreased haemoglobin percentage and increase in ESR. When infestation is not severe and curative measures are taken, gills of fishes regenerate and fishes return to normal. D.
*extensus* is also known to cause dactylogyrosis in common carp from the Amur river in USSR. It is found in large numbers not only in young fishes but also in large fishes and intensity increases with the age of fish. Its population is limited in summer and is less dangerous than *D. vastator*. Prognosis of disease includes fish becoming disquiet approaching en mass the water influx, feed poorly and lag in growth; gills become unevenly coloured and damage to respiratory folds occurs. Single layered epithelium is transferred into a multilayer. There is extensive secretion of mucous which impairs the respiratory function and causes respiratory asphyxiation. Phytophagous fishes from Amur river are also known to suffer from dactylogyrosis due to *D. lamellatus* Achmerow, 1952 and *D. ctenopharyngodonis* Achmerow, 1952. Most frequently infested fishes are those that are in the second year of their life. The parasite is found in large number in mid summer when water temperature is very high.

Bauer et al. (1977) also described gyrodactylosis in freshwater fishes in USSR. *G. katharineri* Malmberg, 1964, *G. medius* Kathariner, 1894, *G. cyprini* Diarova, 1964, and *G. sprostonae* Li Mo-en, 1962 are all incriminated as pathogens. White amur is infested with *G. ctenopharyngodonis* Li Mo-en, 1962. *G. katharineri* and *G. medius* infest the surface of the body while *G. sprostonae* is found to infest gills of fishes. With massive infestation, a bluish film forms on the body.
surface and fins of carp and damage to the tissue of the fins is observed between rays. In some cases skin is damaged and flat ulcers are formed. A non-uniform colouration of gills along with traumatization and necrosis of large sections is obvious in the infested gills. The diseased fish lag in growth. The pathologic effect of *Gyrodactylus* Nordmann, 1832 is manifested not only as direct damage to the tissues of the fish, but also disruption of the respiratory function when the gills and skin covers are damaged.

Macmillan (1985), in his book on Channel Catfish Culture, has discussed the incidence of *Cladodiscus pricei* Mueller, 1935 and *C. floridanus* Mueller, 1936 on the gills of channel catfish. The parasite is said to cause problems in small fishes when present in large number. They are said to interfere with respiration. Another monogenean *Gyrodactylus ictaluris* Rogers, 1967 is said to kill fry and fingerlings of channel catfish when present in large numbers. The infestation may cause increased mucous production and results in blue colouration of skin.

Schaperclaus (1991) have added quite some details on epizootiology of dactylogyrosis due to *Dactylogyrus vastator*; *D. extensus*; *D. anchoratus* (Dujardin, 1845) Wagener, 1857; *D. minutus* Kulwiec, 1927; *D. lamellatus*; *D. tuba* Linstow, 1878; *D. macracanthus* Wagener, 1909; *D.*
crassus Kulwic, 1927; and gyrodactylosis due to Gyrodactylus sprostonae; G. katharineri; G. medius; G. cyprini; G. elegans Nordmann, 1832; and G. ctenopharyngodonis. He has also described epizootiology of tetraonchiosis due to Tetraonchus monenteron Diesing, 1858; T. borealis Olsson, 1933 and T. alaskensis Price, 1937; ancylodiscoidosis due to Ancylodiscoides siluri (Zandt, 1924) Yamaguti, 1937 and A. vistulensis (Siwak, 1932) Yamaguti, 1963; ancyroccephalosis due to Ancryocephalus paradoxus Creplin, 1839 and other closely related genera (Urocleidus (Mueller, 1834) Mueller, 1936, Cleidodiscus Mueller, 1934).

Summing up, monogeneans are an extremely important group of parasites and have a lot of phylogenetic significance. Their oncomiracidia offer tremendous scope for developmental studies on oncotaxy and building up of a natural scheme of classification. The basis of extremely narrow host specificity and speciation offers a very great challenge. It is also fairly obvious that we hardly know about the osmoregulation in monogenea or even physiology and biochemistry in sufficient details. The digeneans, cestodes and nematodes are much better known physiologically. Even the studies in incidence, prognosis and the status of the disease caused by monogeneans is far from being fully appreciated. Monogeneans, being ectoparasitic, offer a
tremendous scope for in vitro cultivation and experiments on anthelmintics. Further, there is hardly any work on the immune response in fish and the potential of immunoprophylaxis against these parasites in fish. In our country, as ill luck would have it, there is some stray work on freshwater forms, mainly due to the efforts of Agrawal (1980,'81,'88), Agarwal and Kumar (1977,'89), Agrawal and Singh (1982 a,b), Baugh (1957), Chauhan (1953 a,b), Dayal (1941), Fotedar et al. (1970), Fotedar and Parveen (1987), Gupta (1982,'83), Gupta and Sharma (1981, '82), Gussev (1976), Jain (1952 a,b, '55, '57 a,b,c, '58, '59 a,b,c,d, '60, '61 a,b), Kaw (1950), Kulkarni (1969 a,b,c, '70, '71, '72, '80), Pandey (1973), Price (1938 a), Srivastava (1975), Swarup (1978, '81), Thapar (1948), Tripathi (1959, '75), Venkatanarsaiah (1979) and Venkatnarsaiah and kulkarni (1980 a,b). Barring Gussev (1976), all others are routine descriptions of new forms and perhaps a dig here and there on systematics. In Madhya Pradesh, more so, in this Chattisgarh area at Raipur there is not even a nodding familiarity with these worms. This has been largely because these worms are microscopic and require a lot of perseverance and patience to separate them from their gill habitat. Being very small in size they do not lend themselves easily to microscopy; biochemical and physiological investigations are tenuous. Realizing the tremendous potential and possibilities of work on monogenea in fishes at Raipur, this
work was undertaken. Because of the time constraint I admit that the predilection in this thesis has been on the systematic survey of freshwater fishes at Raipur for their monogenean faunae and threadbare studies on their morphology and taxonomy. It was also possible to investigate some aspects of physiology, biochemistry, and pathophysiology through histochemical methods. In vitro cultivation of these parasites was also contemplated but on account of limitation of time it has not been possible to do a lot in this respect. This dissertation includes two sections, namely, Section A, including morphology, systematics and seasonal occurrence of monogenean species from freshwater fishes at Raipur; and Section B, including Parasite physiology and host pathophysiology.