CHAPTER 4

RESULTS AND DISCUSSION

DISTRIBUTION PATTERNS OF MONOGENEANS

4.1 Introduction

The aim of this thesis was to document the monogenean species on the freshwater siluriform fishes of Thailand in order to reveal and to elucidate the distribution patterns of the different types of monogeneans. The monogenean species obtained from the freshwater siluriform fishes of Thailand during the course of this study have been identified and described and the descriptions of these monogeneans are given in Appendices 3.1-3.8 (Section 2.3.2). In this Chapter, the distribution of the different monogeneans on different freshwater siluriforms in Thailand will be analysed and compared with monogenean species from the siluriforms from other biogeographic regions in order:

(a) to determine the number and types of species and genera infecting the siluriforms,

(b) to determine the host-specificity of the monogeneans obtained, and

(c) to determine the affinity of the Thai monogeneans.

4.2 Host-monogenean data (Tables 4.1 & 4.2)

The number of fish examined, infected fish, number of monogeneans collected are summarised from Appendices 3.1-3.8 and tabulated in Table 4.1. The prevalence and mean intensity are calculated and also tabulated (Table 4.1). Forty four catfish species from 21 genera and eight families from 32 localities in Thailand were examined for monogeneans (see Section 3.3). Eighty-three monogenean species were found on 40 of 44 fish host species examined (Table 4.1). These 83 species have been identified to belong to *Bifurcohaptor* Jain, 1958 (two species), *Bychowskyella* Achmerow, 1952 (eight species), *Cornudiscoides* Kulkarni, 1969 (13 species), *Hamatopeduncularia* Yamaguti, 1953 (two species), *Mizelleus* Jain, 1957 (one species), *Quadriacanthus* Paperna, 1961 (two species) and *Thaparocleidus* Jain, 1952 (55 species) (Table 4.2) (Appendices 3.1-3.8).

Table 4.1 Host-monogenean data

Fish species	Monogenean species	No. of fish examined (infected)	No.of monogeneans collected	Prevalence (%)	Mean intensity
Ariidae					
Hemipimelodus borneensis	*Hamatopeduncularia longicopulatrix* Lim, 1996	5 (1)	2	20	2
	Hamatopeduncularia n. sp. 1	5 (4)	12	80	3
Bagridae					
Bagrichthys macropterus	-	5 (0)	0	0	0
Batasio tengara	*Thaparocleidus* n. sp. 1	1 (1)	6	100	6
Hemibagrus nemurus	*Bifurcohaptor baungi* Lim & Furtado,19833	42 (3)	5	7	2
	Bifurcohaptor n. sp. 1	42 (2)	6	5	3
	Cornudiscoides malayensis Lim, 1987	42 (25)	142	60	6
	Cornudiscoides selangoricus Lim, 1987	42 (15)	36	36	2
	Cornudiscoides sundanensis Lim, 1987	42 (14)	51	33	4
	Thaparocleidus n. sp. 2	42 (24)	121	57	5
	Thaparocleidus n. sp. 3	42 (24)	84	57	4
	Thaparocleidus n. sp. 4	42 (33)	313	79	9
Hemibagrus wyckoides	*Cornudiscoides* n. sp. 1	12 (9)	66	75	7
	Cornudiscoides n. sp. 2	12 (3)	24	25	8
	Thaparocleidus n. sp. 5	12 (5)	18	42	4
	Thaparocleidus n. sp. 6	12 (8)	91	67	11
	Thaparocleidus n. sp. 7	12 (10)	159	83	16
	Thaparocleidus n. sp. 8	12 (8)	115	67	14
	Thaparocleidus n. sp. 9	12 (6)	101	50	17
Hemibagrus wyckii	-	6 (0)	0	0	0
Mystus atrifasciatus	*Cornudiscoides germinus* Gussev, 1976	4 (4)	25	100	6
	Thaparocleidus n. sp. 10	4 (3)	23	75	8
Mystus bocourti	*Cornudiscoides* n. sp. 3	5 (3)	14	60	5
	Thaparocleidus n. sp. 11	5 (4)	8	80	2
Mystus gulio	*Cornudiscoides* n. sp. 4	3 (3)	14	100	5
	Cornudiscoides n. sp. 5	3 (2)	14	67	6
Mystus mysticetus	*Cornudiscoides* n. sp. 6	1 (1)	20	100	20
	Thaparocleidus n. sp. 12	1 (1)	8	100	8
	Thaparocleidus n. sp. 13	1 (1)	100	100	100

Table 4.1 cont'd

Fish species	Monogenean species	No. of fish examined (infected)	No.of monogeneans collected	Prevalence (%)	Mean intensity
Mystus singaringan	*Cornudiscoides anchoratus* Lim, 1987	9 (8)	63	89	9
	Cornudiscoides bagri Lim, 1987	9 (8)	103	96	13
	Cornudiscoides faciirrus Lim, 1987	9 (5)	28	56	6
	Thaparocleidus n. sp. 14	9 (5)	35	56	7
Mystus wolffii	*Cornudiscoides* n. sp. 5	6 (6)	64	100	11
Pseudomystus siamensis	*Thaparocleidus* n. sp. 15	9 (8)	58	89	7
Claridae					
Clarias batrachus	*Bychowskyella tchangi* Gussev, 1976	12 (6)	41	50	7
	Bychowskyella n. sp. 1	12 (4)	46	33	11
	Quadriacanthus kobiensis Ha, 1968	12 (9)	68	75	8
Clarias cataractus	*Quadriacanthus kobiensis*	5 (4)	21	80	5
Clarias gariepinus	*Quadriacanthus bagrae* Paperna, 1979	4 (2)	76	50	38
Clarias macrocephalus	*Bychowskyella tchangi*	16 (9)	68	56	8
	Quadriacanthus	16 (9)	55	56	6
Clarias meladerma	*Bychowskyella teysmanni* Lim, 1991	4 (2)	5	50	3
	Bychowskyella n. sp. 2	4 (3)	9	75	3
	Quadriacanthus kobiensis	4 (1)	4	25	4
Clarias nieuhofi	*Bychowskyella* n. sp. 3	11 (7)	74	64	11
	Bychowskyella n. sp. 4	11 (7)	55	64	8
	Bychowskyella n. sp. 5	11 (4)	10	36	3
The *Clarias* hybrid	*Quadriacanthus bagrae*	27 (9)	121	33	13
	Gyrodactylus sp.	27 (7)	11	26	2
Heteropneustidae					
Heteropneustes fossilis	*Bychowskyella tchangi*	10 (5)	5	50	1
	Gyrodactylus sp.	10 (7)	25	70	4
Pangasiidae					
Helicophagus waandersii	Thaparocleidus *caecus* (Mizelle & Kritsky, 1969) Lim, 1996	7 (6)	161	86	27
	Thaparocleidus n. sp. 16	7 (5)	74	71	14
	Thaparocleidus n. sp. 17	7 (7)	73	100	10

Table 4.1 cont'd

Fish species	Monogenean species	No. of fish examined (infected)	No.of monogeneans collected	Prevalence (%)	Mean intensity
Pangasianodon gigas	-	7 (0)	0	0	0
Pangasianodon hypophthalmus	*Thaparocleidus caecus*	9 (4)	240	44	60
	Thaparocleidus siamensis (Lim, 1990) Lim, 1996	9 (8)	258	89	32
Pangasius bocourti	*Thaparocleidus* n. sp. 17	8 (7)	44	88	6
	Thaparocleidus n. sp. 18	8 (3)	19	38	6
Pangasius conchophilus	*Thaparocleidus caecus*	10 (9)	76	90	8
	Thaparocleidus n. sp. 16	10 (3)	9	30	3
	Thaparocleidus n. sp. 19	10 (5)	32	50	6
	Thaparocleidus n. sp. 20	10 (6)	48	60	8
Pangasius krempfi	*Thaparocleidus caecus*	2 (2)	26	100	13
	Thaparocleidus n. sp. 17	2 (2)	9	100	5
	Thaparocleidus n. sp. 21	2 (2)	9	100	5
Pangasius larnaudii	*Thaparocleidus caecus*	4 (4)	56	100	14
	Thaparocleidus n. sp. 22	4 (2)	11	50	6
	Thaparocleidus n. sp. 23	4 (4)	14	100	4
	Thaparocleidus n. sp. 24	4 (2)	8	100	4
	Thaparocleidus n. sp. 25	4 (4)	39	100	10
	Thaparocleidus n. sp. 26	4 (3)	55	75	18
Pangasius macronema	*Thaparocleidus* n. sp. 27	11 (8)	44	73	6
	Thaparocleidus n. sp. 28	11 (10)	61	92	6
	Thaparocleidus n. sp. 29	11 (9)	42	82	5
	Thaparocleidus n. sp. 30	11 (5)	12	45	2
Pangasius sanitwongsei	*Thaparocleidus* n. sp. 26	2 (2)	5	100	3
Pteropangasius pleurotaenia	*Thaparocleidus caecus*	7 (2)	11	29	6
	Thaparocleidus n. sp. 27	7 (3)	43	43	14
	Thaparocleidus n. sp. 28	7 (2)	10	29	5
	Thaparocleidus n. sp. 29	7 (4)	11	57	3
	Thaparocleidus n. sp. 31	7 (2)	8	29	4
	Thaparocleidus n. sp. 32	7 (3)	8	43	3
Schilbeidae					
Laides hexanema	*Thaparocleidus* n. sp. 33	4 (4)	23	100	6
	Thaparocleidus n. sp. 34	4 (4)	19	100	5

Table 4.1 cont'd

Fish species	Monogenean species	No. of fish examined (infected)	No.of monogeneans collected	Prevalence (%)	Mean intensity
Siluridae					
Belodontichthys dinema	*Thaparocleidus* n. sp. 35	4 (4)	139	100	35
	Thaparocleidus n. sp. 36	4 (4)	77	100	19
Hemisilurus mekongensis	*Thaparocleidus* n. sp. 37	1 (1)	5	100	7
	Thaparocleidus n. sp. 38	1 (1)	6	100	5
Kryptopterus apogon	*Thaparocleidus* n. sp. 39	5 (3)	18	60	6
	Thaparocleidus n. sp. 40	5 (3)	28	60	7
Kryptopterus bicirrhis	*Thaparocleidus* n. sp. 41	2 (2)	25	100	49
	Thaparocleidus n. sp. 42	2 (2)	98	100	13
Kryptopterrus bleekeri	*Thaparocleidus* n. sp. 39	9 (4)	191	44	48
	Thaparocleidus n. sp. 40	9 (5)	58	56	12
	Thaparocleidus n. sp. 44	9 (3)	30	33	10
	Thaparocleidus n. sp. 45	9 (2)	8	22	4
Kryptopterus cryptopterus	*Thaparocleidus* n. sp. 42	6 (4)	66	67	17
	Thaparocleidus n. sp. 43	6 (2)	42	33	21
	Thaparocleidus n. sp. 44	6 (3)	8	50	3
Ompok bimaculatus	*Thaparocleidus* n. sp. 46	22 (9)	18	41	2
	Thaparocleidus n. sp. 47	22 (13)	31	59	2
	Thaparocleidus n. sp. 48	22 (16)	82	73	5
	Thaparocleidus n. sp. 49	22 (20)	230	91	12
Silurichthys sp.	*Thaparocleidus* n. sp. 50	3 (2)	17	67	9
Wallago attu	*Mizelleus siamensis* Lim & Lerssutthichawal, 1996	5 (5)	59	100	12
	Thaparocleidus indicus (Kulkarni, 1969) Lim, 1996	5 (4)	28	80	7
	Thaparocleidus kao Lim & Lerssutthichawal, 1996	5 (5)	64	100	13
Sisoridae					
Bagarius bagarius	*Thaparocleidus* n. sp. 51	6 (2)	29	33	14
Bagarius yarrelli	-	2 (0)	0	0	0
Glyptothorax major	*Bychowskyella sisoris* Lim, 1991	2 (2)	10	100	7

Table 4.2 Number of monogenean species on Thai freshwater catfish (Bif = *Bifurcohaptor*; Cor = *Cornudiscoides*; Tha = *Thaparocleidus*; Byc = *Bychowskyella*; Ham = *Hamatopeduncularia*; Miz = *Mizelleus*; Qua = *Quadriacanthus*; Gyr = *Gyrodactylus*

Fish host species	No. of fish examined	No. of fish infected	No. of monogenean species									
			Ancylodiscoidinae				Ancyrocephalinae			Gyr	No. of genera	No. of species
			Bif	Cor	Tha	Byc	Ham	Miz	Qua			
Ariidae:	**5**	**4**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**1**	**2**
Hemipimelodus borneensis	5	4	-	-	-	-	2	-	-	0	1	2
Bagridae:	**103**	**79**	**2**	**13**	**15**	**0**	**0**	**0**	**0**	**0**	**3**	**30**
Bagrichthys macropterus	5	0	-	-	-	-	-	-	-	0	0	0
Batasio tengara	1	1	-	-	1	-	-	-	-	0	1	1
Hemibagrus nemurus	42	33	2	3	3	-	-	-	-	0	3	8
Hemibagrus wyckoides	12	11	-	2	5	-	-	-	-	0	2	7
Hemibagrus wyckii	6	0	-	-	-	-	-	-	-	0	0	0
Mystus atrifasciatus	4	4	-	1	1	-	-	-	-	0	2	2
Mystus bocourti	5	4	-	1	1	-	-	-	-	0	2	2
Mystus gulio	3	3	-	2	-	-	-	-	-	0	1	2
Mystus mysticetus	1	1	-	1	2	-	-	-	-	0	2	3
Mystus singaringan	9	8	-	3	1	-	-	-	-	0	2	4
Mystus wolffii	6	6	-	1	-	-	-	-	-	0	1	1
Pseudomystus siamensis	9	8	-	-	1	-	-	-	-	0	1	1
Clariidae:	**79**	**54**	**0**	**0**	**0**	**7**	**0**	**0**	**2**	**1**	**3**	**10**
Clarias batrachus	12	11	-	-	-	2	-	-	1	0	2	3
Clarias cataractus	5	4	-	-	-	-	-	-	1	0	1	1
Clarias gariepinus	4	2	-	-	-	-	-	-	1	0	1	1
Clarias macrocephalus	16	10	-	-	-	1	-	-	1	0	2	2
Clarias meladerma	4	4	-	-	-	2	-	-	1	0	2	3
Clarias nieuhofi	11	7	-	-	-	3	-	-	-	0	1	3
Clarias hybrid	27	16	-	-	-	-	-	-	-	1	1	1
Heteropneustidae:	**10**	**7**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**2**	**2**
Heteropneustes fossilis	10	7	-	-	-	1	-	-	-	1	2	2

Table 4.2 cont'd

Fish host species	No. of fish examined	No. of fish infected	No. of monogenean species									
			Ancylodiscoidinae				Ancyrocephalinae			Gyr	No. of genera	No. of species
			Bif	Cor	Tha	Byc	Ham	Miz	Qua			
Pangasiidae:	67	58	0	0	19	0	0	0	0	0	1	19
Helicophagus waandersii	7	7	-	-	3	-	-	-	-	0	1	3
Pangasianodon gigas	7	0	-	-	-	-	-	-	-	0	0	0
Pangasianodon hypophthalmus	9	9	-	-	2	-	-	-	-	0	1	2
Pangasius bocourti	8	7	-	-	2	-	-	-	-	0	1	2
Pangasius conchophilus	10	10	-	-	4	-	-	-	-	0	1	4
Pangasius krempfi	2	2	-	-	3	-	-	-	-	0	1	3
Pangasius larnaudii	4	4	-	-	6	-	-	-	-	0	1	6
Pangasius macronema	11	11	-	-	4	-	-	-	-	0	1	4
Pangasius sanitwongsei	2	1	-	-	1	-	-	-	-	0	1	1
Pteropangasius pleurotaenia	7	7	-	-	6	-	-	-	-	0	1	6
Schilbeidae:	4	4	0	0	2	0	0	0	0	0	1	2
Laides hexanema	4	4	-	-	2	-	-	-	-	0	1	2
Siluridae:	57	51	0	0	18	0	0	1	0	0	2	19
Belodontichthys dinema	4	4	-	-	2	-	-	-	-	0	1	2
Hemisilurus mekongensis	1	1	-	-	2	-	-	-	-	0	1	2
Kryptopterus apogon	5	3	-	-	2	-	-	-	-	0	1	2
Kryptopterus bicirrhis	2	2	-	-	2	-	-	-	-	0	1	2
Kryptopterus bleekeri	9	8	-	-	4	-	-	-	-	0	1	4
Kryptopterus cryptopterus	6	6	-	-	3	-	-	-	-	0	1	3
Ompok bimaculatus	22	20	-	-	4	-	-	-	-	0	1	4
Silurichthys sp.	3	2	-	-	1	-	-	-	-	0	1	1
Wallago attu	5	5	-	-	2	-	-	1	-	0	2	3
Simoridae:	10	4	0	0	1	1	0	0	0	0	2	2
Bagarius bagarius	6	2	-	-	1	-	-	-	-	0	1	1
Bagarius yarrelli	2	0	-	-	-	-	-	-	-	0	0	0
Glyptothorax major	2	2	-	-	-	1	-	-	-	0	1	1

No monogenean was found on the following four siluriforms: *Bagrichthys macropterus* (Bagridae) (five specimens examined), *Hemibagrus wyckii* (Bagridae) (six specimens), *Pangasianodon gigas* (Pangasiidae) (seven specimens) and *Bagarius yarrelli* (Sisoridae) (two specimens) (Table 4.2). A total of 335 siluriform specimens were examined, and only 263 individuals (78 %) were found to be infected with monogeneans. *Heteropneustes fossilis* (seven specimens) and *Clarias* hybrid (seven specimens) were infected with *Gyrodactylus*, which were not described in this study due to low number of specimens obtained.

4.2.1 Ariidae

Thus far only brackish water and marine ariids have been examined for monogeneans and 47 species have been recorded: *Hamatopeduncularia* Yamaguti, 1953 (20 species), *Chauhanellus* Bychowsky & Nagibina, 1969 (21 species), *Neocalceostoma* Tripathi, 1957 (one species) and *Neocalceostomoides* Kritsky, Mizelle & Bilqees, 1978 (five species) (Appendix 1). These four monogenean genera are found on the ariid fishes from the Pacific Ocean to the Indian Ocean (see Kearn & Whittington, 1994; Kritsky, Mizelle & Bilqees, 1978; Lim, 1994, 1995a, 1996a; Siddiqui & Kulkarni, 1983; Tripathi, 1957; Venkatanarsaiah & Kulkarni, 1990; Whitthington & Kearn, 1995; Young, 1967; Zhang & Ding, 1993) (Appendix 1).

***Hemipimelodus* Bleeker, 1858**

Two species of *Hamatopeduncularia* Yamaguti, 1953 were obtained from four of the five specimens of *Hemipimelodus borneensis* examined. The two *Hamatopeduncularia* species are *Hamatopeduncularia longicopulatrix* Lim, 1996 and one new species of *Hamatopeduncularia* (Table 4.1 & Appendix 3.1: Monogeneans of Ariidae). The type host of *H. longicopulatrix* is *Arius venosus*, a marine ariid in Peninsular Malaysia.

This is the first time that *Hamatopeduncularia* has been recorded on a freshwater ariid. In Australia *Hamatopeduncularia* and *Chauhanellus* were found on *Arius graeffei* which have migrated into the freshwater systems (Kearn & Whittington, 1994; Whittington & Kearn, 1995). This indicates the ability of *Hamatopeduncularia* and *Chauhanellus* to withstand a wide and varying range of

salinities. Investigations into the physiology of these monogeneans will elucidate how monogeneans are able to adapt to macro-environment changes.

Summary

Although four monogenean genera, *Chauhanellus* (21 species), *Hamatopeduncularia* (20 species), *Neocalceostoma* (one species) and *Neocalceostomoides* (five species) have been recorded from marine ariids (*Arius* and *Osteogeneiosus*) (see Kritsky, Mizelle & Bilqees, 1978; Lim, 1994, 1995a, 1996a; Siddiqui & Kulkarni, 1983; Tripathi, 1957 & Appendix 1), only two species of *Hamatopedun-cularia* are found on the Thai freshwater ariid, *Hemipimelodus borneensis*.

4.2.2 Bagridae

Twelve species of bagrid fishes belonging to six genera were examined for monogeneans (see Table 3.2: Chapter 3). Except for *Bagrichthys macropterus* and *Hemibagrus wyckii*, the other ten bagrid species were infected with 30 monogenean species (22 new species and eight previously described species) (Table 4.1 & Appendix 3.2: Monogeneans of Bagridae). The 30 monogenean species obtained belong to three genera; *Thaparocleidus* Jain, 1952 (15 species), *Cornudiscoides* Kulkarni, 1969 (13 species) and *Bifurcohaptor* Jain, 1958 (two species) (Tables 4.1 & 4.2). These three monogenean genera also have been recorded from the bagrids of India and Peninsular Malaysia.

To date, a total of 42 monogenean species have been collected from bagrid species in Indian subcontinent (24 monogenean species from seven bagrid species), Peninsular Malaysia (seven monogenean species from two bagrid species), China (six monogenean species from seven bagrid species), Russia (four monogenean species from three bagrid species) and Africa (two monogenean species from three bagrid species) (Appendices 1 & 3.2). There are records of monogenean species on the other two bagrid genera from India, *Aorichthys* and *Rita* which are not found in Thailand. Four monogenean species (one species of *Ancylodiscoides* Yamaguti, 1937 and three species of *Thaparocleidus* Jain, 1952) were found on *Aorichthys aor*, while three monogenean species (one species each of *Bifurcohaptor*, *Hamatopeduncularia* and *Thaparocleidus*) were found on *A. seenghala*. Two

monogenean species (one species each of *Bychowskyella* Achmerow, 1952 and *Thaparocleidus*) were found on *Rita rita* (see Appendices 1 & 3.2). The presence of *Hamatopeduncularia* (usually found on ariids) on Indian bagrid is probably a misidentification. The monogenean genera infecting the bagrid species in Africa and Asia are different. *Quadriacanthus* Paperna, 1961 is the only genus found on the African bagrids, whilst there are five monogenean genera on Asian bagrids: *Ancylodiscoides*, *Bifurcohaptor*, *Bychowskyella*, *Cornudiscoides* and *Thaparocleidus* (Table 4.1). Closely related to the African bagrid is the Claroteidae (formerly Bagridae) which is endemic to Africa and it is infected with *Bagrobdella* Paperna, 1969 and *Protoancylodiscoides* Paperna, 1969 (Appendix 1).

***Bagrichthys* Bleeker, 1853**

No monogenean was found on the five specimens of *Bagrichthys macropterus* examined in this study. Thus far, there is no record of monogeneans on this host genus.

***Batasio* Blyth, 1860**

A new species of *Thaparocleidus* was found on *Batasio tengara*.(Tables 4.1 & 4.2) This is the first time that monogenean is recorded on *B. tengara*, although this fish species is also found in Malaysia and the Indian subcontinent.

***Hemibagrus* Bleeker, 1864**

Eight monogenean species belonging to three genera were obtained from *Hemibagrus nemurus*; *Thaparocleidus* (three species), *Cornudiscoides* (three species) and *Bifurcohaptor* (two species), while five species of *Thaparocleidus* and two species of *Cornudiscoides* were found on *H. wyckoides* (Table 4.1). No monogenean was present on *H. wyckii*. The three *Cornudiscoides* species and one species of *Bifurcohaptor* found on *H. nemurus* of this study were previously described from Malaysian *H. nemurus* (syn. *Mystus nemurus*), viz., *Cornudiscoides malayensis* Lim, 1987, *Cornudiscoides selangoricus* Lim, 1987, *Cornudiscoides sundanensis* Lim, 1987 and *Bifurcohaptor baungi* Lim & Furtado, 1983) (see Lim, 1987b; Lim & Furtado, 1983).

Previous works have recorded ten monogenean species found on Malaysian *H. nemurus* (see Lim, 1987a); six species of *Thaparocleidus*, three species of *Cornudiscoides* and one species of *Bifurcohaptor*. In China, the *Hemibagrus* species were infected with two monogenean genera, *Ancylodiscoides* and *Bychowskyella*. *Hemibagrus macropterus* is host to one species of *Ancylodiscoides* and one species of *Bychowskyella*, while *H. elongatus* and *H. guttatus* were infected with one species of *Bychowskyella*. *Bychowskyella pseudobagri* Achmerow, 1952 was also found on the bagrid fishes of the genus *Pelteobagrus* (*Pelteobagrus brashnikowi* and *P. fulvidraco*) in Russia and China (see Appendix 1). Thus far, there is no record of *Bychowskyella* on Southeast Asian *Hemibagrus*.

***Mystus* Scopoli, 1777**

Thirteen monogenean species were obtained from six *Mystus* species in this study: eight species of *Cornudiscoides* (four of eight are new species) and five new species of *Thaparocleidus* (Tables 4.1 & 4.2; Appendix 3.2). *Mystus bocourti* (syn. *Heterobagrus bocourti*) has one new *Cornudiscoides* species and one new *Thaparocleidus* species, while *M. singaringan* possesses three species of *Cornudiscoides* (*Cornudiscoides anchoratus* Lim, 1987, *Cornudiscoides bagri* Lim, 1987 and *Cornudiscoides facicirrus* Lim, 1987) and one new *Thaparocleidus* species. *C. anchoratus* Lim, 1987, *C. bagri* Lim, 1987 and *C. facicirrus* Lim, 1987 were first described from Malaysian *M. nigriceps*. *M. gulio* (an estuarine and freshwater fish) has two new *Cornudiscoides* species. *M. wolffii* shares one *Cornudiscoides* species with *M. gulio*. *Cornudiscoides germinus* Gussev, 1976 and a new species of *Thaparocleidus* were found on Thai striped *Mystus*, *M. atrifasciatus*. *C. germinus* was first described from the Indian *M. vittatus*. Another Thai striped *Mystus*, *M. mysticetus* possesses three new species of monogeneans (one *Cornudiscoides* and two *Thaparocleidus*) (Table 4.1). No *Bifurcohaptor* was found on *Mystus* in this study.

Currently, 18 species of monogeneans from four genera are recorded on five *Mystus* species in the Indian subcontinent (16 monogenean species from five *Mystus* species) and Peninsular Malaysia (three monogenean species from one *Mystus* species). The five genera are *Cornudiscoides* (11 species), *Thaparocleidus* (three

species), *Bifurcohaptor* (two species), *Bychowskyella* (one species) and *Gyrodactylus* (one species) (Appendix 3.2). In Peninsular Malaysia only *Cornudiscoides*, *Thaparocleidus* and *Bifurcohaptor* have been recorded. No *Bychowskyella* has been found to date on Malaysian *Mystus*.

***Pseudomystus* Jayaram, 1968**

One new species of *Thaparocleidus* was found on *Pseudomystus siamensis* in this study (Table 4.1 & Appendix 3.2). *Parancyrocephaloides leiocassis* Reichenbach-Klinke, 1959 was described from this fish species (which was formerly known as *Leiocassis siamensis*) exported from Thailand to Europe (see Reichenbach -Klinke, 1959). The type species for *Parancyrocephaloides* is *Parancyrocephaloides daicoci* Yamaguti, 1938 described from a marine fish, *Daicocus peterseni* (Dactylopteridae) (see Yamaguti, 1963). Subsequently another species, *Parancyrocephaloides indicus* Kulkarni, 1969, was described from another marine fish in India *Clupea harengus* (see Kulkarni, 1969c). The two species, *P. daicoci* and *P. indicus* suggest that *Parancyrocephaloides* is probably a marine monogenean and not a parasite of freshwater siluriforms (Gussev, 1976, 1978; Lim, 1988). The species described by Reichenbach-Klinke (1959) could be a *Thaparocleidus* species.

Summary

The Thai bagrid fishes possess 30 monogenean species belonging to three genera: *Bifurcohaptor* (two species), *Cornudiscoides* (13 species) and *Thaparocleidus* (15 species). Within the bagrid species, *Hemibagrus nemurus* has the highest number of monogenean species (eight species), followed by *H. wyckoides* (seven species). In Malaysia, *H. nemurus* were found to be infected with ten monogenean species from these three genera (see Lim, 1987a).

Six monogenean genera have been recorded on the bagrids. Only one genus *Quadriacanthus* is found on the bagrids (*Bagrus*) in Africa, while Asian bagrids are hosts to the other five genera: *Ancylodiscoides* on *Aorichthys* in India and on *Pseudobagrus* in China, *Bifurcohaptor* and *Cornudiscoides* on *Mystus* and *Hemibagrus* in India and Southeast Asia, *Bychowskyella* on *Hemibagrus* and *Pelteobagrus* in China, and *Thaparocleidus* from at least eight Asian bagrid genera

(Appendix 3.2 & present data). Although *Quadriacanthus* are widely found on clariids, in both Africa, India and Southeast Asia, it is also found on *Bagrus* species in Africa but not bagrids in elsewhere. *Bychowskyella* can also be found on bagrids of the Amur-Chinese region, but not the bagrids of India and Southeast Asia. In India and Southest Asia *Bychowskyella* are found on clariids (Section 4.2.3), silurids (Section 4.2.7) and sisorids (Section 4.2.8). *Bifurcohaptor* and *Cornudiscoides* are restricted to the bagrids of India and Southeast Asia.

4.2.3 Clariidae

Five genera of monogeneans have been reported from the Clariidae: *Bychowskyella* Achmerow, 1952, *Quadriacanthus* Paperna, 1961 *Paraquadriacanthus* Ergens, 1988, *Gyrodactylus* Nordmann, 1832 and *Macrogyrodactylus* Malmberg, 1957 (see El-Naggar & Serag, 1985; Ergens, 1988; Gussev, 1976; Ha, 1968; Hanek & Furtado, 1973; Kritsky, 1990; Kritsky & Kulo, 1988; Lerssutthichawal & Lim, 1997; Lim, 1990a, 1991b; Lim & Furtado, 1983; Long, 1981; Paperna, 1961, 1969, 1979). To date there are 19 species belonging to five genera of monogeneans infecting the Clariidae: *Quadriacanthus* (ten species), *Bychowskyella* (four species), *Gyrodactylus* (three species), *Paraquadriacanthus* (one species), and *Macrogyrodactylus* (one species) (Appendix 3.3: Monogeneans of Clariidae and Heteropneustidae). The other African clariid, *Heterobranchus* also possesses *Quadriacanthus* (see Paperna, 1969). *Paraquadriacanthus* Ergens, 1988 (from nasal cavity) and *Macrogyrodactylus* Paperna, 1969 were also recorded from the African clariids, but are thus far not found on Asian clariids.

Clarias Scopoli, 1777

Clarias is the only genus of clariids examined from Thailand. Two species of *Quadriacanthus*, seven species of *Bychowskyella* and one species of *Gyrodactylus* were obtained from seven species of *Clarias* Scopoli, 1777 (Table 4.1; Appendices 3.3 & 3.9). *Quadriacanthus kobiensis* Ha, 1968 was found on four *Clarias* species: *Clarias batrachus*, *C. cataractus*, *C. macrocephalus* and *C. meladerma*. *Quadriacanthus bagrae* Paperna, 1979 was obtained from *C. gariepinus* (syn. *C. lazera*) and the *Clarias* hybrid (crossbred between *C. gariepinus* and *C.*

macrocephalus). *Quadriacanthus kobiensis* was first recorded from *C. fuscus* in Vietnam (see Ha, 1968), and later found on *C. batrachus* in India, and Peninsular Malaysia and now Thailand (see Gussev, 1976; Lim & Furtado, 1983; present study). *Clarias cataractus*, *C. macrocephalus* and *C. meladerma* are the new host species records for *Q. kobiensis* (see Lerssutthichawal & Lim, 1997). This indicates that *Q. kobiensis* has not only a wide host range but also a wide geographical range.

Of the seven species of *Bychowskyella* obtained, two are known species; *Bychowskyella tchangi* Gussev, 1976 from *C. batrachus* and *C. macrocephalus* and *Bychowskyella teysmanni* Lim, 1991 from *C. meladerma*. The other five are new species of *Bychowskyella* obtained from *C. batrachus* (one *Bychowskyella* species), *C. meladerma* (one *Bychowskyella* species) and *C. nieuhofi* (three *Bychowskyella* species) (Table 4.1 & Appendix 3.3). *Bychowskyella tchangi* was first found on Indian *C. batrachus* and was also recorded from Malaysian *C. batrachus* and presently from Thai *C. batrachus* and *C. macrocephalus*, while *B. teysmanni* was found on Malaysian *C. teysmanni* and Thai *C. meladerma* (see Gussev, 1976; Lim, 1991b; Lerssutthichawal & Lim, 1997). *Clarias gariepinus* introduced into Thailand has only one species of *Quadriacanthus*, *Q. bagrae* Paperna, 1979. Seven *Quadriacanthus* species were recorded from *C. gariepinus* (see El-Naggar & Serag, 1985; Ergens, 1988; Kritsky, 1990; Kritsky & Kulo, 1988; Paperna, 1961, 1969, 1979).

Summary

Clarias batrachus is widely distributed in India, Southeast Asia and Indo-China. In fact the same monogenean species, *Bychowskyella tchangi* is found on *C. batrachus* in all three regions. However, *Quadriacanthus kobiensis* is found on *C. batrachus* in India and Southeast Asia but not in South China. There are seven species of *Quadriacanthus* recorded on *C. gariepinus* in the original habitat (Africa), but only *Q. bagrae* was found on *C. gariepinus* imported into Thailand. This suggests that only *Q. bagrae* can adapt to survive in the different habitats. The present five new *Bychowskyella* species increase the number of monogeneans in the clariids to 24 species.

In Africa clariids are infected with *Gyrodactylus*, *Macrogyrodactylus*, *Paraquadriacanthus* and *Quadriacanthus* (see Appendix 3.3), while in Asia the clariids are hosts to *Gyrodactylus*, *Bychowskyella* and *Quadriacanthus* (Gussev, 1976; Ha, 1968; Hanek & Furtado, 1973; Lerssutthichawal & Lim, 1997; Lim, 1991b; Lim & Furtado, 1983; Long, 1981; present data)

Previous record lists a *Dactylogyrus* on a *Clarias* species (both wild and cultured) in Thailand (see Section 1.3). This is definitely a misidentification and the species is probably either a *Quadriacanthus* or a *Bychowskyella* species (see Table 1.6; Section 1.3).

4.2.4 Heteropneustidae

***Heteropneustes* Muller, 1840**

Only one species of *Heteropneustes* Muller, 1840 were examined. *Bychowskyella tchangi* Gussev, 1976 and *Gyrodactylus* sp. were obtained from the ten specimens of *Heteropneustes fossilis* examined (Table 4.1). Thus far, only *Bychowskyella fossilisi* Majumdar & Agarwal, 1988 and *Gyrodactylus gussevi* Dubey, Gupta & Agarwal, 1990 were described from Indian *H. fossilis*. However, the description and illustrations given for *B. fossilisi* by Majumdar and Agarwal (1988) indicate that this species is similar to *B. tchangi* from *C. batrachus* (see Gussev, 1976). It is possible that *B. fossilisi* could be a synonym of *B. tchangi* (see Appendix 3.3: Monogeneans of Clariidae and Heteropneustidae).

Summary

Bychowskyella and *Gyrodactylus* are two monogenean genera recorded from *Heteropneustes fossilis* in India. Thai fish specimens were also infected with these two monogenean genera. *Bychowskyella tchangi* which is the monogenean of the Clariidae is also found on Thai *H. fossilis*. Whilst in Indian fish specimens *B. fossilisi* was recorded (Majumdar & Agarwal, 1988).

4.2.5 Pangasiidae

Ten pangasiid species belonging to four genera were examined for monogeneans. Nineteen species of *Thaparocleidus* were obtained from nine pangasiid species (Table 4.1 & Appendix 3.4: Monogeneans of Pangasiidae). No monogenean was found on *Pangasianodon gigas*. Of the 19 *Thaparocleidus* species, two are known species, *Thaparocleidus caecus* (Mizelle & Kritsky, 1969) Lim, 1996 and *T. siamensis* (Lim, 1990) Lim, 1996,

To date only four species of monogeneans have been described from pangasiids: *Thaparocleidus caecus* (Mizelle & Kritsky, 1969) Lim, 1996, *Thaparocleidus siamensis* (Lim, 1990) Lim, 1996, *Thaparcoleidus campylopterocirrus* (Zeng, 1988) Lim, 1996 and *Thaparcoleidus pangasi* (Tripathi, 1957) Lim, 1996. *T. caecus* was first described as *Ancylodiscoides caecus* Mizelle & Kritsky, 1969 from an unknown aquarium fish (see Mizelle & Kritsky, 1969) and this species was subsequently found on *Pangasianodon hypophthalmus* (formerly *Pangasius sutchi*) imported from Thailand to Peninsular Malaysia (see Lim, 1990b, 1996b). *T. siamensis* was first described from an imported *P. hypophthalmus* in Peninsular Malaysia (see Lim, 1990b, 1996b). *T. pangasi* is from the Indian *Pangasius pangasius* (see Tripathi, 1957; Lim, 1996b).

Helicophagus Bleeker, 1858

Helicophagus waandersii is the sole representative species of the genus *Helicophagus* found in Thailand. *T. caecus* and two new species of *Thaparocleidus* were obtained (Table 4.1 & Appendix 3.4).

Pangasianodon Chevey, 1930

The two species of *Pangasianodon* (*P. gigas and P. hypophthalmus*) were examined. No monogenean was found on all seven individuals of *Pangasianodon gigas*, while *T. caecus* and *T. siamensis* were found on *P. hypophthalmus*. These two monogenean species were described from *P. hypophthalmus* (syn. *Pangasius sutchi*) imported from Thailand for culture in Peninsular Malaysia (see Lim, 1990b; 1996b). In China, *P. hypophthalmus* was infected by *T. campylopterocirrus* which is similar to *T. siamensis* (see Lim, 1996b).

***Pangasius* Valenciennes, 1840**

Thaparocleidus caecus and 15 new *Thaparocleidus* species were obtained from the six *Pangasius* species examined in this study. *Pangasius larnaudii* possesses the highest number of *Thaparocleidus* species (with *T. caecus* and five new *Thaparocleidus* species), followed by *P. conchophilus* (with *T. caecus* and three new *Thaparocleidus* species) and *P. macronema* (with four new *Thaparocleidus* species).

T. caecus and two new *Thaparocleidus* species were found on *P. krempfi*, while two new *Thaparocleidus* species were found on *P. bocourti*. *Pangasius sanitwongsei* possesses only one species of *Thaparocleidus* which was also found on *P. larnaudii* (Table 4.1 & Appendix 3.4).

***Pteropangasius* Fowler, 1937**

Pteropangasius pleurotaenia was examined and found to be infected with *T. caecus* and five new *Thaparocleidus* species. Three of these five new species were also found on *Pangasius macronema* (Table 4.1 & Appendix 3.4).

Summary

All the monogenean species found on pangasiid fishes belong to the *Thaparocleidus* (19 species). Of the two *Pangasianodon* species examined, *P. hypophthalmus* were always infected with high prevalence and mean intensity (for example the prevalence for *T. siamensis* is 89 % prevalence with a mean intensity of 32), while *P. gigas* (from cultured pond) were uninfected (Tables 4.1 & 4.2). The absence of monogenean specimens on *P. gigas* could probably be due to either the changes in habitats and other environmental factors and/or the chemicals used during the nursing period. *Pangasius larnaudii* and *Pteropangasius pleurotaenia* have the highest number of *Thaparocleidus* species (six species each). *T. caecus* is the most common species being found on at least six pangasiid species.

4.2.6 Schilbeidae

Currently, eight species of *Bychowskyella* and five species of *Thaparocleidus* were recorded on schilbeids from India (Dubey, Gupta & Agarwal, 1992a; Gussev, 1976, 1977; Jain, 1957b, 1959, 1961b; Lim, 1996b; Majumdar & Agarwal,

1988; Tripathi, 1957) (Appendix 3.5: Monogeneans of Schilbeidae). Unlike the Asian schilbeids, the African schilbeids were infected with *Schilbetrema* Paperna & Thurston, 1968 (12 species) and *Schilbetrematoides* Kritsky & Kulo, 1992 (one species) (see El-Naggar, 1985; Kritsky & Kulo, 1992a, 1992b; Paperna, 1969, 1973, 1979; Paperna & Thorston, 1968) (Appendix 3.5).

***Laides* Jordan, 1919**

Two new species of *Thaparocleidus* were obtained from *Laides hexanema* (Table 4.1 & Appendix 3.5). This is the first time that monogeneans are recorded from *L. hexanema*.

Summary

Schilbeid fishes from different regions possess different monogenean genera. In Thailand the schilbeids as represented by *L. hexanema* possesses *Thaparocleidus* species, while the Indian schilbeids (*Eutropiichthys*, *Silonia* and *Pseudeutropius*) possess both *Bychowskyella* and *Thaparocleidus* species. Thus far only *L. hexanema* was examined, It would be interesting to note whether *Bychowskyella* could be found on the other Thai schilbeids, *Clupisoma*, *Eutropiichthys* and *Platytropius*. The African schilbeids (*Schilbe* and *Physalia*), on the other hand, possess *Schilbetrema* and *Schilbetrematoides* (see Appendix 3.5). This could imply that the Asian and African schilbeids and their respective monogeneans could have differentiated allopatrically (see Section 3.4). It will be interesting to test this premise.

4.2.7 Siluridae

Nine species of silurid fishes belonging to six genera were examined for monogeneans and all were found to be infected. One species of *Mizelleus* and 18 species of *Thaparocleidus* were obtained from the nine silurids (Table 4.1 & Appendix 3.6: Monogeneans of Siluridae). *Mizelleus siamensis* Lim & Lerssutthichawal, 1996, *Thaparocleidus indicus* (Kulkarni, 1969) Lim, 1996 and *Thaparocleidus kao* Lim & Lerssutthichawal, 1996 were described from Thai *Wallago attu* (see Lim & Lerssutthichawal, 1996: Appendix 3.8).

Currently, there are 72 recorded monogenean species from 13 genera on silurid species (see Gussev, 1978; Lim, 1991b, 1996b; Lim & Lerssutthichawal, 1996) (Appendix 1). Lim (1996b) has recently synonymised six of the 13 monogenean genera found on silurids as the synonyms of *Thaparocleidus* (see Section 4.3.1). It is probable that there are only 68 species in four monogenean genera on the silurids. The silurids seem to possess high species diversity per host species as shown by the presence of 27 species belonging to three genera (*Thaparocleidus*, *Ancylodiscoides* and *Gyrodactylus*) on *Silurus asotus* (Appendix 1).

***Belodontichthys* Bleeker, 1858**

Two species of *Thaparocleidus* were found on *Belodontichthys dinema* (Table 4.1 & Appendix 3.6). This is the first time that monogeneans are recorded from this fish species.

***Hemisilurus* Bleeker, 1858**

Two new species of *Thaparocleidus* were obtained from *Hemisilurus mekongensis* in this study (Table 4.1 & Appendix 3.6).

***Kryptopterus* Bleeker, 1858**

Four species of *Kryptopterus* were examined for monogeneans and all were found to be infected with seven new *Thaparocleidus* species: *Kryptopterus apogon* (with two *Thaparocleidus* species); *K. bicirrhis* (with two *Thaparocleidus* species), *K. bleekeri* (with four *Thaparocleidus* species) and *K. cryptopterus* (with three *Thaparocleidus* species) (Table 4.1 & Appendix 3.6). Four of these new *Thaparocleidus* species could be found on more than one fish species: *K. cryptopterus* shared one species with *K. bicirrhis*, and another with *K. bleekeri*, while *K. apogon* shared two species with *K. bleekeri* (Tables 4.1 & 4.2).

Two unidentified species of *Ancylodiscoides* were found on *K. apogon* from Ubonratana Reservoir, Thailand (see Chinabut, 1981). These two species probably belong to the genus *Thaparocleidus*. Currently there is only one species of

Thaparocleidus found on the two species of *Kryptopterus*, *K. apogon* and *K. bicirrhis*, from Peninsular Malaysia (see Lim, 1987a).

***Ompok* Lacepede, 1803**

Ompok bimaculatus is the only species of the genus *Ompok* examined in this study (Section 3.3.2.10). Four new species of *Thaparocleidus* were found on this fish species (Table 4.1 & Appendix 3.6).

In India, three species of *Thaparocleidus* and one species of *Bychowskyella* were obtained from two species of *Ompok* (see Jain, 1959; Gussev, 1976, 1977; Appendix 1), while five species of *Thaparocleidus* have been recorded from *Ompok hypophthalmus* (syn. *Silurodes hypophthalmus*) in Peninsular Malaysia (see Lim, 1986a). Thus far, no *Bychowskyella* was recorded from *Ompok* species in Southeast Asia.

***Silurichthys* Bleeker, 1856**

A new species of *Thaparocleidus* was collected from *Silurichthys* sp. of Thailand (Table 4.1 & Appendix 3.6). In Peninsular Malaysia *Bychowskyella baueri* Lim, 1991 and one species of *Thaparocleidus* have been found on *Silurichthys hasselti* (see Lim, 1987a, 1991b). Unlike Malaysian *Silurichthys*, no *Bychowskyella* was found so far on Thai *Silurichthys*.

***Wallago* Bleeker, 1851**

Three species of monogeneans, *Mizelleus siamensis* Lim & Lerssutthichawal, 1996, *Thaparocleidus kao* Lim & Lerssutthichawal, 1996 and *T. indicus* (Kulkarni, 1969) Lim, 1996 were obtained from *Wallago attu* (Table 4.1 & Appendix 3.8).

To date 29 monogenean species from 13 genera have been described from both Thai and Indian *W. attu* (see Lim & Lerssutthichawal, 1996 & Appendix 1). It is probable that there are only two monogenean genera, *Mizelleus* and *Thaparocleidus*, on *W. attu* and the rest are either misidentifications and synonyms (Lim & Lerssutthichawal, 1996). Lim and Lerssutthichawal (1996) suggest that five of the 13 monogenean genera recorded, *Neocalceostoma*, *Dactylogyrus*, *Hamatopeduncularia*,

Heteronchocleidus and *Urocleidus* are misidentifications. This is because *Dactylogyrus* is a genus found mainly on cyprinids; while *Neocalceostoma* and *Hamatopeduncularia* are restricted to ariids (see also Lim, 1995a, 1996a), *Heteronchocleidus* is a monogenean of anabantoid fishes (see also Lim, 1986b) and *Urocleidus* is found only on North American catfish, and not on Old World catfish. *Wallagotrema* Tripathi, 1957 is another genus found on Indian *W. attu*. This monogenean genus is probably synonymous to *Mizelleus* or *Thaparocleidus* (see Lim & Lerssutthichawal, 1996).

Wallago leerii was not examined in this study, however, three species of *Thaparocleidus* were found on Malaysian *W. leerii* (see Lim, 1987a).

Summary

Nineteen monogenean species from two genera, *Thaparocleidus* (18 species) and *Mizelleus* (one species) were collected from nine silurid species in Thailand. The four species of *Kryptopterus* were found to share some *Thaparocleidus* species. The diversity of *Thaparocleidus* in the Siluridae of Southeast Asia is comparatively lower than that of the temperate silurids. *Ompok bimaculatus* of Thailand possesses four *Thaparocleidus* species and *O. hypophthalmus* in Peninsular Malaysia has five *Thaparocleidus* species, while *Silurus asotus* in the Palearctic region were found to be infected with 25 *Thaparocleidus* species (see Appendix 1). However, this apparently low diversity in tropical fish gills could be due to infrequent sampling (Lim, 1998).

4.2.8 Sisoridae

Three species of *Bifurcohaptor* and three species of *Bychowskyella* have been found on sisorids of India, Peninsular Malaysia and China. *Bifurcohaptor gorakhnathai* Kumar & Agarwal, 1982, *Bifurcohaptor son* (Tripathi, 1957) Kulkarni, 1969, *Bifurcohaptor vishwanathai* Agarwal & Kumar 1977, *Bychowskyella bagariusi* Sharma, 1983 are found on *Bagarius bagarius* in India, *Bychowskyella sisoris* Lim, 1991 described from *Glyptothorax major* in Malaysia and *Glyptothorax sinense* from China was infected with *Bychowskyella glyptothoraci* Ma, Wang & Li, 1983 (Appendices 1 & 3.7: Monogeneans of Sisoridae).

***Bagarius* Bleeker, 1853**

Bagarius bagarius and *B. yarrelli* are two species of *Bagarius* examined for monogeneans. A new species of *Thaparocleidus* was collected from *B. bagarius* (Table 4.1 & Appendix 3.7). No monogenean specimen was found on *B. yarrelli* in this study. This is the first time that *Thaparocleidus* was recorded from *B. bagarius*. Unlike the Indian *B. bagarius*, no *Bychowskyella* and *Bifurcohaptor* species were found on the Thai *B. bagarius*.

***Glyptothorax* Blyth, 1860**

Bychowskyella sisoris was also found on *G. major* in Thailand.

Summary

Thus far two monogenean genera were recorded from sisorids, *Bifurcohaptor* (three species) from Indian *Bagarius bagarius*, and *Bychowskyella* (three species) from Indian *B. bagarius*, Southeast Asian *Glyptothorax major* and Chinese *G. sinense*. Unlike the Indian *B. bagarius*, only *Thaparocleidus* (one species) was found on Thai *B. bagarius*.

4.3 Discussion

The above Sections summarisd the monogeneans found on the siluriforms surveyed in this study. In the following sections the taxonomic status of the monogeneans obtained during the course of this study will be discussed before discussing the diversity and specificity of the monogeneans obtained.

4.3.1 Ancyrocephalidae Bychowsky, 1937

Taxonomically the monogeneans of the siluriforms from the Old World are included within the subfamilies Ancylodiscoidinae Gussev, 1961 and Ancyrocephalinae Bychowsky, 1937 in the family Ancyrocephalidae Bychowsky, 1937 (see Gussev, 1978; Lim, 1988). These two subfamilies are differentiated on the

basis of the morphology of the seminal vesicles: genera with blind sac-like seminal vesicles are included in the Ancylodiscoidinae, while genera with dactylogyrid-type seminal vesicles are in the Ancyrocephalinae (see Lim, 1996a, 1992c; Lim & Lerssutthichawal, 1996).

Thirteen monogenean genera have been recorded on the catfish of the Oriental and Palearctic regions. Eight of these genera are found on freshwater catfish, while the other five genera are from marine siluriforms species. Five of the eight freshwater genera belong to the Ancylodiscoidinae: *Ancylodiscoides* Yamaguti, 1937, *Bifurcohaptor* Jain, 1958, *Cornudiscoides* Kulkarni, 1969, *Pseudancylodiscoides* Yamaguti, 1963 and *Thaparocleidus* Jain, 1952 (see Gussev, 1976, 1978, 1985; Lim, 1987b, 1996b, 1998; Lim & Furtado, 1983). While the other three genera are placed in the Ancyrocephalinae: *Bychowskyella* Achmerow, 1952, *Quadriacanthus* Paperna, 1961, and *Mizelleus* Jain, 1957 (see Lim, 1998; Lim & Lerssutthichawal, 1996).

The five monogenean genera on marine catfishes are *Anchylodiscus* Johnston & Tiegs, 1922 in the subfamily Ancylodiscoidinae, *Hamatopeduncularia* Yamaguti, 1953 and *Chauhanellus* Bychowsky & Nagibina, 1969 in the subfamily Ancyrocephalinae, and *Neocalceostoma* Tripathi, 1957 and *Neocalceostomoides* Kritsky, Mizelle, & Bilqees, 1978 in the family Neocalceostomatidae Lim, 1995. The *Anchylodiscus* and *Hamatopeduncularia* could be found on both marine and freshwater plotosids and ariids, respectively (see Lim, 1992c, 1996a).

The family Ancyrocephalidae, in particular the subfamily Ancyrocephalinae, is a heterogenous and an 'unnatural' grouping (see Kritsky & Boeger, 1989). The status of the Ancyrocephalidae will be discussed in details in Chapter 6. Herein it is suffice to say that the family Ancyrocephalidae as proposed by Bychowsky and Nagibina (1978) (see also Gussev, 1978; Lim, 1998) will be retained until a more detailed revision could be done (see Section 6.2).

(i) Ancylodiscoidinae Gussev, 1961

Three of the five genera of Ancylodiscoidinae are found on freshwater catfish of Thailand. The three genera are *Bifurcohaptor* Jain, 1958 (two species), *Cornudiscoides* Kulkarni, 1969 (13 species) and *Thaparocleidus* Jain, 1952 (55 species) which make up 2 %, 17 % and 66 % of the monogenean obtained, respectively (Tables 4.3 & 4.4).

Table 4.3 Diversity of monogeneans on Thai freshwater catfishes

Monogenean genera	No. of monogenean species	Percentage (%)	No. of fish spp. infected	No. of fish genera infected	No. of fish families infected
Ancylodiscoidinae Gussev, 1961	**(70)**	**(85)**			
Thaparocleidus Jain, 1952	55	66	28	16	5
Cornudiscoides Kulkarni, 1969	13	17	8	2	1
Bifurcohaptor Jain, 1958	2	2	1	1	1
Ancyrocephalinae Bychowsky, 1937	**(13)**	**(15)**			
Bychowskyella Achmerow, 1952	8	10	6	3	2
Hamatopeduncularia Yamaguti, 1953	2	2	1	1	1
Mizelleus Jain, 1957	1	1	1	1	1
Quadriacanthus Paperna, 1961	2	2	6	1	1
Total 7 genera	83 species				

Table 4.4 Monogenean-host data

Monogenean genera	Fish families	Fish host genera (No. of species)	No. of monogenean species
Ancylodiscoidinae:			
Bifurcohaptor	Bagridae	*Hemibagrus* (1)	2
Cornudiscoides	Bagridae	*Hemibagrus* (2)	5
		Mystus (6)	8
Thaparocleidus	Bagridae	*Batasio* (1)	1
		Hemibagrus (2)	8
		Mystus (4)	5
		Pseudomystus (1)	1
	Pangasiidae	*Helicophagus* (1)	3
		Pangasianodon (1)	2
		Pangasius (6)	16
		Pteropangasius (1)	6
	Schilbeidae	*Laides* (1)	2
	Siluridae	*Belodontichthys* (1)	2
		Hemisilurus (1)	2
		Kryptopterus (4)	7
		Ompok (1)	4
		Silurichthys (1)	1
		Wallago (1)	2
	Sisoridae	*Bagarius* (1)	1
Ancyrocephalinae:			
Bychowskyella	Clariidae	*Clarias* (4)	7
	Heteropneustidae	*Heteropneustes* (1)	1
	Sisoridae	*Glyptothorax* (1)	1
Hamatopeducularia	Ariidae	*Hemipimelodus* (1)	2
Mizelleus	Siluridae	*Wallago* (1)	1
Quadriacanthus	Clariidae	*Clarias* (6)	2

(a) *Bifurcohaptor* Jain, 1958

Two species of *Bifurcohaptor* were obtained from *Hemibagrus nemurus* (Bagridae) in the present study (Table 4.4). One of the two species is *Bifurcohaptor baungi* Lim & Furtado, 1983 which was first described from *H. nemurus* (syn. *Mystus nemurus*) in Peninsular Malaysia; the other is a new species. No *Bifurcohaptor* species was found on sisorid fishes in this survey although three *Bifurcohaptor* species were recorded from Indian *Bagarius bagarius* (see Agarwal & Kumar, 1977; Kumar & Agarwal, 1982; Tripathi, 1957).

Hitherto, seven species of *Bifurcohaptor* were recorded from the Oriental region on two fish families, Bagridae and Sisoridae with four and three species, respectively. The four species of *Bifurcohaptor* from bagrids are from *Hemibagrus* (with one *Bifurcohaptor* species) and *Mystus* (with three *Bifurcohaptor* species). The three species from sisorids are from *Bagarius bagarius* (Table 4.5). The seven *Bifurcohaptor* species are recorded in the Oriental region of India, Sri Lanka and Peninsular Malaysia. In India the *Bifurcohaptor* is found on *Mystus* species and *B. bagarius*, while in Southeast Asia *Bifurcohaptor* is recorded on *Hemibagrus nemurus* and *Mystus* species (see Lim, 1987a; Lim & Furtado, 1983; present data). *Bifurcohaptor* is absent from *B. bagarius* of Thailand.

Table 4.5 Diversity and distribution of *Bifurcohaptor* species (B = Bagridae, S = Sisoridae)

Bifurcohaptor species	Fish host species	Localities	References
1. *B. baungi*	*Hemibagrus nemurus* (B)	Penin. Malaysia	Lim & Furtado, 1983
		Thailand	present study
2. *B. giganticus*	*Aorichthys aor* (B)	India	Jain, 1958; Gussev, 1978
3. *B. gorakhnathai*	*Bagarius bagarius* (S)	India	Kumar & Agrawal, 1982
4. *B. indicus*	*Mystus vittatus* (B)	India	Jain, 1958; Kulkarni, 1969b
			Gussev, 1976
5. *B. lanki*	*M. keletius* (B)	Sri Lanka	Gussev, 1976
6. *B. son*	*Bagarius bagarius*	India	Tripathi, 1957;
			Kulkarni
7. *B. vishwanathai*	*B. bagarius*	India	Agrawal & Kumar, 1977
8. *Bifurcohaptor* n. sp.1	*Hemibagrus nemurus*	Thailand	present study

(b) *Cornudiscoides* Kulkarni, 1969

Thirteen species of *Cornudiscoides* were obtained from eight bagrid fish species of two genera, *Hemibagrus* (five *Cornudiscoides* species) and *Mystus* (eight *Cornudiscoides* species). No *Cornudiscoides* species was found on the other three bagrids (*Bagrichthys macropterus*, *Pseudomystus siamensis* and *Batasio tengara*) examined in this study (Tables 4.4 & 4.6).

Table 4.6 Diversity and distribution of *Cornudiscoides* species

Cornudiscoides species	Fish host species	Localities	References
1. *C. anchoratus*	*Mystus nigriceps*	Penin. Malaysia	Lim, 1987b
	Mystus singaringan	Thailand	present study
2. *C. bagri*	*M. nigriceps*	Penin. Malaysia	Lim, 1987b
	M. singaringan	Thailand	present study
3. *C. facicirrus*	*M. nigriceps*	Penin. Malaysia	Lim, 1987b
	M. singaringan	Thailand	present study
4. *C. germinus*	*Mystus vittatus*	India	Gussev, 1976
	Mystus atrifasciatus	Thailand	present study
5. *C. heterotylus*	*Mystus tengara*	India	Kulkarni, 1969b
6. *C. jaini*	*Mystus keletius*	Sri Lanka	Gussev, 1963; Gussev, 1976
7. *C. malayensis*	*Hemibagrus nemurus*	Penin. Malaysia	Lim, 1987b
		Thailand	present study
8. *C. megalorchis*	*M. tengara*	India	Kulkarni, 1969b
9. *C. microtylus*	*M. tengara*	India	Kulkarni, 1969b
10. *C. proximus*	*M. vittatus*	India	Gussev, 1976
11. *C. raipurensis*	*M. vittatus*	India	Dubey, Gupta & Agarwal, 1992b
12. *C. selangoricus*	*H. nemurus*	Penin. Malaysia	Lim, 1987b
		Thailand	present study
13. *C. sundanensis*	*H. nemurus*	Penin. Malaysia	Lim, 1987b
		Thailand	present study
14. *C. vittati*	*M. vittatus*	India	Dubey, Gupta & Agarwal, 1992b
15. *Cornudiscoides* n.sp.1	*Hemibagrus wyckoides*	Thailand	present study
16 *Cornudiscoides* n.sp.2	*H. wyckoides*	Thailand	present study
17. *Cornudiscoides* n.sp.3	*Mystus bocourti*	Thailand	present study
18. *Cornudiscoides* n.sp.4	*Mystus gulio*	Thailand	present study
19. *Cornudiscoides* n.sp.5	*M. gulio*	Thailand	present study
20. *Cornudiscoides* n.sp.6	*Mystus mysticetus*	Thailand	present study

Thus far 14 *Cornudiscoides* species have been described from Indian and Southeast Asian bagrids. There are no records of *Cornudiscoides* on the Chinese and African bagrids. *Cornudiscoides* are thus restricted to the Bagridae of the Oriental region and probably to the fish genera, *Hemibagrus* and *Mystus* (see Lim, 1987a). The present six new *Cornudiscoides* species brings the number of *Cornudiscoides* species to 20 (Table 4.6).

(c) *Thaparocleidus* Jain, 1952

In 1996, Lim assigned *Silurodiscoides* Gussev, 1976 as a junior synonym of *Thaparocleidus* Jain, 1952. *Thaparocleidus* has the greatest diversity in terms of number of species. In this study 55 *Thaparocleidus* species (four previously described species and 51 new species) were obtained. Twenty-eight catfish species from 16 genera in five siluriform families examined were infected with *Thaparocleidus* species (Table 4.3). Of the 55 *Thaparocleidus* species, 19 were found on nine pangasiid species, 18 on nine silurid species, 15 on eight bagrid species, two on one schilbeid species (*Laides hexanema*) and one on a sisorid species (*Bagarius bagarius*) (Table 4.4 & Appendices 3.2, 3.4, 3.5, 3.6, 3.7 & 3.8). This is the first time that *Thaparocleidus* is recorded on sisorids.

Besides siluriform fishes, *Thaparocleidus* have also been found on notopterid fishes, *Chitala lopis* (syn. *Notopterus chitala*) and *Notopterus notopterus* (Notopteridae: Osteoglossiformes) (see Jain, 1955; Lim, 1996b; Lim & Furtado, 1986). Lim (1987a) suggested that the presence of *Thaparocleidus* on notopterids which are phylogenetically unrelated to the catfish could be secondarily acquired by the notopterids and probably indicates the antiquity of ancylodiscoidin group.

To date 80 *Thaparocleidus* species were recorded on 22 fish host species from 15 genera of six (siluriform and notopterid) families (see Lim, 1996b; Lim & Lerssutthichawal, 1996). Of the 80 *Thaparocleidus* species, 51 were from the fish species of the Oriental region, while 29 *Thaparocleidus* species were from bagrids (with three *Thaparocleidus* species) and silurids (with 26 *Thaparocleidus* species) of the Palearctic region (Appendix 1).

(ii) Ancyrocephalinae Bychowsky, 1937

This subfamily contains both freshwater and marine genera. This subfamily is recognised as an unnatural groupings by Lim (1998) and a revision is urgently needed. The possibility of reverting to Gussev (1978) original groupings of all genera of monogeneans from catfish into Ancylodiscoidinae is being considered (Lim, pers. com.). However in this thesis the Ancyrocephalinae is retained while noting that a revision is urgently needed.

Four monogenean genera in the subfamily Ancyrocephalinae (see above) were found on the freshwater catfishes of Thailand, viz., *Bychowskyella* Achmerow, 1952 (eight species), *Hamatopeduncularia* Yamaguti, 1953 (two species), *Mizelleus* Jain, 1957 (one species) and *Quadriacanthus* Paperna, 1961 (two species). *Hamatopeduncularia* has a single dactylogyrid-type seminal vesicle, while the other three genera have two dactylogyrid-type seminal vesicles.

(a) *Bychowskyella* Achmerow, 1952

Eight species of *Bychowskyella* (five new and three previously described species) were found on three fish families in Thailand: Clariidae (four *Clarias* species), Heteropneustidae (*Heteropneustes fossilis*) and Sisoridae (*Glyptothorax major*). *Bychowskyella tchangi* Gussev, 1976 was found on *Clarias batrachus*, *C. macrocephalus* and *H. fossilis*, while *B. teysmanni* Lim, 1991 was found on *C. meladerma* in this study. The five new species of *Bychowskyella* were collected from *C. batrachus* (one *Bychowskyella* species), *C. meladerma* (one *Bychowskyella* species) and *C. nieuhofi* (three *Bychowskyella* species) (see Table 4.1; Appendices 3.3 & 3.9).

The 23 previously known species of *Bychowskyella* were found mainly on the catfish in India and Southeast Asia with four species on the catfish from South China and the Amur-Chinese region (Table 4.7). *Bychowskyella* also has a wide host range having been recorded from six fish families, viz., Bagridae, Clariidae, Heteropneustidae, Schilbeidae, Siluridae and Sisoridae. The antiquity of the species within *Bychowskyella* has been postulated based on the presence and / or absence of the onchium on the haptor (see Lim, 1991b). Lim (1991b) suggested that the most

Table 4.7 Diversity and distribution of *Bychowskyella* species

(B = Bagridae, C = Clariidae, H = Heteropneustidae, Sc = Schilbeidae, Si = Siluridae, Ss = Sisoridae; PM = Peninsular Malaysia)

Bychowskyella species	Fish host species	Localities	References
1. *B. asiatica*	*Ompok pubda* (Si)	India	Jain, 1959; Gussev 1976
2. *B. austrofugianensis*	*Clarias fuscus* (C)	China	Long, 1981
3. *B. bagariusi*	*Bagarius bagarius* (Ss)	India	Sharma, 1983
4. *B. baueri*	*Silurichthys_hasselti* (Si)	PM	Lim, 1991
5. *B. bychowskyii*	*Pseudeutropius taakree* (Sc)	India	Gussev, 1977
6. *B. caballeroi*	*Pseudeutropius garua* (Sc)	India	Gussev, 1977
7. *B. cauveryi*	*Silonia silondia* (Sc)	India	Tripathi, 1957; Gussev, 1976
8. *B. fossilisi*	*Heteropneustes fossilis* (B)	India	Majumdar & Agarwal, 1988
9. *B. gharui*	*P. garua*	India	Tripathi, 1957; Gussev, 1976
10. *B. glyptothoraci*	*Glyptothorax sinense* (Ss)	China	Ma, Wang & Li, 1983
11. *B. gomtia*	*Eutropiichthys vacha* (Sc)	India	Jain, 1959; Gussev, 1976
12. *B. gussevi*	*P. garua*	India	Majumdar & Agarwal, 1988
13. *B. kangpurensis*	*Mystus tengara* (B)	India	Gupta & Sachdeva, 1986
14. *B. meridionalis*	*C. fuscus*	China	Long, 1981
15. *B. pricei*	*P. garua*	India	Majumdar & Agarwal, 1988
16. *B. pseudobagri*	*Hemibagrus elongatus* (B)	China	Li & Zhang, 1992
	H. guttatus (B)	China	Li & Zhang, 1992
	H. macropterus (B)	China	Long, 1981
	Pelteobagrus brashnikowi (B)	China	Long, 1981
	P. fulvidraco (B)	China	Long, 1981
17. *B. raipurensis_*	*Rita rita* (B)	India	Majumdar & Agarwal, 1988
18. *B. singhi*	*Wallago attu* (Si)	India	Rajeswari & Kulkarni, 1983
19. *B. sisoris*	*Glyptothorax major* (Ss)	PM	Lim, 1991
		Thailand	present study
20. *B. tchangi*	*Clarias batrachus* (C)	China	Long, 1981
		India	Gussev, 1976
		PM	Lim & Furtado, 1983
		Thailand	Lerssutthichawal & Lim, 1997
	Clarias macrocephalus (C)	PM	Lim, 1991
		Thailand	Lerssutthichawal & Lim, 1997
	Heteropneustes fossilis (H)	Thailand	present study
21. B. *teysmanni*	*Clarias teysmanni* (C)	PM	Lim, 1991
	Clarias meladerma (C)	Thailand	present study

Table 4.7 cont'd

Bychowskyella species	Fish host species	Localities	References
22. *B. vacha*	*E. vacha* (Sc)	India	Tripathi, 1957; Gussev, 1976
23. *B. wallagonia*	*W. attu* (Si)	India	Jain, 1959; Gussev, 1976
24. *Bychowskyella* n. sp.1	*C. batrachus*	Thailand	present study
25. *Bychowskyella* n. sp.2	*C. meladerma*	Thailand	present study
26. *Bychowskyella* n. sp.3	*C. nieuhofi*	Thailand	present study
27. *Bychowskyella* n. sp.4	*C. nieuhofi*	Thailand	present study
28. *Bychowskyella* n. sp.5	*C. nieuhofi*	Thailand	present study

primitive species is the *Bychowskyella* with two onchia and the advanced is the *Bychowskyella* without onchium (see Section 6.4.4).

Bychowskyella was included in subfamily Ancylodiscoidinae by Gussev (1978) and in the subfamily Ancyrocephalinae by Kritsky and Boeger (1989). Lim (1987a) also placed *Bychowskyella* and *Quadriacanthus* within the Ancylodiscoidinae and into the Ancyrocephalinae in 1998.

(b) *Hamatopeduncularia* Yamaguti, 1953

In this study two species of *Hamatopeduncularia*, *H. longicopulatrix* Lim, 1996 and one new *Hamatopeduncularia* species were present on *Hemipimelodus borneensis*, a freshwater ariid, in this study. The 20 previously described *Hamatopeduncularia* species were found on marine ariids and on ariids which migrated from the sea into the freshwater environment (see Lim, 1996a; Kearn & Whittington, 1994). The presence of *H. longicopulatrix* from both marine and freshwater ariids suggests that this monogenean species can tolerate a wide range of salinity. Thus far *H. longicopulatrix* is found on a marine ariid species (*Arius venosus*). *Hamatopeduncularia* have also been recorded from non-ariid fish group such as *Wallago attu* (Siluridae), *Aorichthys seenghala* (Bagridae) and *Terapon theraps* (Teraponidae) (see Agrawal & Sharma, 1988; Karyakarte & Das, 1972; Tewari & Agrawal, 1986b). Lim (1996a) suggested that *Hamatopeducularia* should only be limited to the ariids and that the presence of *Hamatopeduncularia* species on non-ariid catfishes should be re-assessed for possible misidentifications.

(c) *Mizelleus* Jain, 1957

Only one species of *Mizelleus* (*M. siamensis* Lim & Lerssutthichawal, 1996) was found in Thailand on *Wallago attu* (Siluridae) (see Lim & Lerssutthichawal, 1996: Appendix 3.8).

To date, six species of *Mizelleus* have been described from *W. attu*: five species on Indian *W. attu* and one species on Thai *W. attu* (Table 4.8). *Mizelleus* was formerly emplaced in the subfamily Ancylodiscoidinae, has been reassigned into subfamily Ancyrocephalinae because of the presence of two dactylogyrid-type seminal vesicles (see Lim & Lerssutthichawal, 1996).

Table 4.8 Diversity and distribution of *Mizelleus* species on *Wallago attu*

Mizelleus species	Localities	References
1. *M. chauhani*	India	Agrawal & Sharma, 1989
2. *M. hindanensis*	India	Tewari & Agrawal, 1986
3. *M. indicus*	India	Jain, 1957a; Kulkarni, 1969a;
	India	Gussev, 1976
4. *M. lucknowensis*	India	Agrawal & Sharma, 1986
5. *M. siamensis*	Thailand	Lim & Lerssutthichawal, 1996
6. *M. wallagonius*	India	Singh, Kumari & Agrawal, 1992

(d) *Quadriacanthus* Paperna, 1961

Two species of *Quadriacanthus* were collected from four *Clarias* species. *Quadriacanthus kobiensis* Ha, 1968 was found on *C. batrachus*, *C. cataractus*, *C. macrocephalus* and *C. meladerma*, while *Q. bagrae* Paperna, 1979 was found on *C. gariepinus* and on the hybrid of *C. gariepinus* and *C. macrocephalus* (see Appendices 3.3 & 3.9). *Quadriacanthus* has a wide geographical distribution, this genus is found in Indo-China (Ha, 1968; Long, 1981), Southeast Asia (Lerssut-thichawal & Lim, 1997; Lim, 1992a, 1992b; Lim & Furtado, 1983), India (Gussev, 1976) and the Ethiopian region (Kritsky & Kulo, 1988; Paperna, 1961, 1965, 1969, 1973, 1979).

Currently, 11 *Quadriacanthus* species have been recorded from three different fish host families, viz., Clariidae, Bagridae and Cichlidae (see Gussev, 1976; Ha, 1968; Lerssutthichawal & Lim, 1997; Lim & Furtado, 1983; Long, 1981; Paperna, 1965, 1973, 1979; Paperna & Thurston, 1968) (Table 4.9). Thus far, *Quadriacanthus* have been recorded on the African bagrids and cichlids, but not on the Oriental bagrids. According to Paperna (1969), *Quadriacanthus* prefers to infect the clariid fish more than bagrids and cichilds. *Quadriacanthus* is closely related to *Bychowskyella* in having haptoral armaments which are similar morphologically as well as in their development pattern (see Lim & Furtado, 1983; Paperna, 1979). Like *Bychowskyella* and *Mizelleus*, *Quadriacanthus* has just been placed into subfamily Ancyrocephalinae (see Lim & Lerssutthichawal, 1996).

4.3.2 Diversity within monogeneans

As already noted, all 83 monogenean species (excluding *Gyrodactylus*) found on 40 Thai freshwater catfish species belong to the family Ancyrocephalidae. The subfamily Ancylodiscoidinae with 70 species is more diverse than the subfamily Ancyrocephalinae with 13 species. The distribution of the monogenean diversity are summarised in Table 4.3 and Table 4.4.

Of the seven monogenean genera found in this study, *Thaparocleidus* has the highest species diversity (55 species or 66 % of the total monogeneans obtained) and could be found on 28 fish species of 16 genera from five families (Bagridae,

Table 4.9 Diversity and distribution of *Quadriacanthus* species (C, Claridae; B, Bagridae; Ci, Cichlidae)

Quadriacanthus spp.	Fish host spp.	Localities	References
1. *Q. aegypticus*	*Clarias gariepinus* (C)	Egypt	El-Naggar & Serag, 1985
		Egypt	Kritsky & Kulo, 1988
2. *Q. allobychowskiella*	*C. gariepinus*	Uganda	Paperna, 1979
		Egypt	El-Naggar & Serag, 1985
		Egypt	Kritsky & Kulo, 1988
3. *Q. ashuri*	*C. gariepinus*	Egypt	Kritsky & Kulo, 1988
4. *Q. bagrae*	*Bagrus docmac* (B)	Uganda	Paperna, 1979
	B. bayad (B)	Uganda	Paperna, 1979
	B. orientalis (B)	Tanzania	Paperna, 1979
	Clarias gariepinus	Egypt	Kritsky & Kuld, 1988
		Thailand	Lerssutthichawal & Lim, 1997
	Clarias hybrid (C)	Thailand	Lerssutthichawal & Lim, 1997
5. *Q. clariadis*	*C. gariepinus*	Israel	Paperna, 1961
		Egypt	Molnar & Mossalam, 1985
		Egypt	Kritsky & Kulo, 1988
	C. mossambicus (C)	Uganda	Paperna & Thurston, 1968
	Heterobranchus isopterus (C)	Ghana	Paperna, 1969
6. *Q. gyrocirus*	*Clarias batrachus* (C)	China	Long, 1981
7. *Q. kobiensis*	*C. batrachus*	Vietnam	Ha, 1968
		India	Gussev, 1976
		Penin. Malaysia	Lim & Furtado, 1983
		Thailand	Lerssutthichawal & Lim, 1997
	C. fuscus (C)	Vietnam	Ha, 1968
	C. macrocephalus (C)	Thailand	Lerssutthichawal & Lim, 1997
8. *Q. numidus*	*C. gariepinus*	Egypt	Kritsky & Kulo, 1988
9. *Q. papernai*	*C. gariepinus*	Egypt	Kritsky & Kulo, 1988
10. *Q. tilapiae*	*Tilapia esculenta* (Ci)	Uganda	Paperna, 1973
11. *Q. voltaensis*	*Clarias walkeri* (C)	Ghana	Paperna, 1965, 1969

Pangasiidae, Schilbeidae, Siluridae and Sisoridae). *Cornudiscoides* is next with 13 species (17 %), and is restricted to the Bagridae (*Hemibagrus* and *Mystus*). This is followed by *Bychowskyella* with eight species (10 %) found on Clariidae, Heteropneustidae and Sisoridae; *Bifurcohaptor* with two species (2 %) restricted to the Bagridae (*Hemibagrus*); *Quadriacanthus* with two species (2 %) from the Clariidae; *Hamatopeduncularia* with two species found only on the freshwater Ariidae; and *Mizelleus* with one species on the Siluridae (Tables 4.3 & 4.4).

4.3.3 Diversity of monogeneans on catfish

In this section diversity is defined in terms of species number or species richness (see Section 6.3.1).

4.3.3.1 On different host families

Table 4.2 shows that the bagrids have the greatest monogenean species diversity with 30 species of monogeneans belonging to three monogenean genera, *Bifurcohaptor* (two species), *Cornudiscoides* (13 species) and *Thaparocleidus* (15 species). The pangasiids and silurids are next with 19 monogenean species each. All the 19 monogenean species from pangasiids belong to *Thaparocleidus*, whilst silurids are infected with two monogenean genera, *Mizelleus* (one species) and *Thaparocleidus* (18 species). The clariids possess nine monogenean species from two genera, *Quadriacanthus* (two species) and *Bychowskyella* (seven species), while heteropneustid possesses one species of *Bychowskyella*. Sisorids on the other hand have two species from two monogenean genera, *Bychowskyella* (one species) and *Thaparocleidus* (one species). The freshwater Ariidae as represented by *Hemipimelodus*, has only one monogenean genus, *Hamatopeduncularia* with two species. The monogenean diversity within the host family is correlated to the diversity of the host families. The number of species or monogenean species diversity for each fish family is dependent on the diversity of the fish host species in the family concerned. The Bagridae, for example, with 12 host species, has the highest diversity in monogenean species (30 species), while Pangasiidae and Siluridae with ten and nine host species, respectively, have 19 monogenean species each.

4.3.3.2 On different host genera and species

The number of monogenean species per catfish host species in Thailand ranges from one to eight (Table 4.10). *Hemibagrus nemurus* has the highest number of monogenean species with eight species from three genera (Table 4.2): *Thaparocleidus* and *Cornudiscoides* with three species each, and *Bifurcohaptor* (two species). The diversity of species per host species vary from one to six in the pangasiids, two *Thaparocleidus* species were found on *P. bocourti*, while six *Thaparocleidus* species were collected from *P. larnaudii*.

Table 4.10 Monogenean distribution pattern on different fish hosts

(*Gyrodactylus* not included)

Fish host families	No. of fish host species									Total
	No. of monogenean species on each fish species									
	0	1	2	3	4	5	6	7	8	
Ariidae	-	-	1	-	-	-	-	-	-	1
Bagridae	2	3	3	1	1	-	-	1	1	10
Clariidae	-	3	1	3	-	-	-	-	-	7
Heteropneustidae	-	1	-	-	-	-	-	-	-	1
Pangasiidae	1	1	2	2	2	-	2	-	-	9
Schilbeidae	-	-	1	-	-	-	-	-	-	1
Siluridae	-	1	4	2	2	-	-	-	-	9
Sisoridae	1	2	-	-	-	-	-	-	-	2
Total	4	11	12	8	5	0	2	1	1	44
Percentage (%)	9	25	28	18	11	0	5	2	2	100

4.3.3.3 Multispecies monogenean community on the fish hosts

Fish species usually possess more than one monogenean species. The co-existing species could be congeneric species (species belonging to the same genus) or sympatric species (different monogenean species, genera or families, which share the same host species) (see Lim, 1987a).

In this study 29 fish host species (66 %) of the 44 examined fish host species possess more than one monogenean species, while 11 species (25 %) were infected with only one monogenean species (Table 4.10). The majority of Thai freshwater catfish (12 fish host species or 28 %) usually have two co-existing congeners, while 18 % have three co-existing species. Of the 83 monogenean species obtained, 78 species (94 %) could be found together with other monogenean species, whilst only five species are found alone: *Bychowskyella sisoris* on *Glyptothorax major*, *Thaparocleidus* n. sp. 1 on *Batasio tengara*, *Thaparocleidus* n. sp. 15 on *Pseudomystus siamensis*, *Thaparocleidus* n. sp. 50 on *Silurichthys* sp. and *Thaparocleidus* n. sp. 51 on *Bagarius bagarius*.

In this study the highest number of sympatric monogenean species is eight, found on *H. nemurus*: two species of *Bifurcohaptor*, three species of *Cornudiscoides* and three species of *Thaparocleidus*. This number is comparatively lower than that of the same fish host species in Peninsular Malaysia which possesses ten monogenean species from three genera: *Thaparocleidus* (six species), *Cornudiscoides* (three species) and *Bifurcohaptor* (one species) (see Lim, 1987a). *Hemibagrus* (*H. nemurus* and *H. wyckoides*) habours more monogenean species than other fish host species.

4.3.4 Monogenean-host distribution patterns: Specificity

Previous studies as well as the present data (see Table 4.4 & Appendix 1) indicate that certain genera and families of monogeneans are restricted to certain groups of fish hosts, although there are some monogeneans that are capable of infecting a wide range of hosts (see Gussev, 1978; Lim, 1990a; Rohde, 1993; present data).

Host specificity is the direct result of co-evolution with a particular host (see Brooks, 1979, 1986, 1989; Lim, 1987a; Rohde, 1993). Host specificity can be narrow or wide depending on the monogenean species concerned. Several hypotheses

have been founded to explain wide host specificity. Wide host specificity, could be due to the ability of the host to exchange the parasites (see Leong & Holmes, 1981; Lim, 1987a).

Specificity is exhibited by monogeneans at generic and familial levels. As mentioned in section 4.3.1 only two monogenean families, Ancyrocephalidae and Neocalceostomatidae are present on catfish. Within the Ancyrocephalidae, subfamily Ancylodiscoidinae is mainly found on catfish (except some species on notopterids; see Lim & Furtado, 1986), while subfamily Ancyrocephalinae is a heterogenous group which possesses a number of genera and species and can be found on a wide range of fish host groups, such as on the Characiformes, Cypriniformes, Perciformes and Siluriformes (see Ergens, 1988; Kritsky & Boeger, 1995; Kritsky & Kulo, 1988, 1992a, 1992b; Lim, 1987a; Paperna, 1969; Paperna & Thurston, 1968).

4.3.4.1 At familial and generic levels

Among the seven monogenean genera found in this study, *Cornudiscoides* and *Hamatopeduncularia* are specific to particular host genera and families: *Cornudiscoides* is restricted to *Hemibagrus* or *Mystus* (Bagridae), while *Hamatopeduncularia* is found only on the ariids. Unlike *Hamatopeduncularia* and *Chauhanellus* (Ancyrocephalinae) and *Neocalceostoma* and *Neocalceostomoides* (Neocalceostomatidae) have been recorded from marine ariids only (see Lim, 1994, 1995a, 1996a). One genus not found in this study is the *Anchylodiscus* which was recorded from estuarine and marine plotosids (see Lim, 1992c; Paperna, 1977).

Bychowskyella and *Thaparocleidus* could be found on a wide variety of fish families, whilst the other five monogenean genera; *Bifurcohaptor*, *Cornudiscoides*, *Mizelleus*, *Quadriacanthus* and *Hamatopeduncularia* have a limited host range. *Bychowskyella* is present on the Bagridae, Clariidae, Heteropneustidae, Schilbeidae, Siluridae and Sisoridae; while *Thaparocleidus* is found on Bagridae, Pangasiidae, Schilbeidae, Siluridae and Sisoridae and on non-siluriform Notopteridae (see Lim, 1996b); *Quadriacanthus* is restricted to Clariidae in the Oriental region, but it occurs on the Clariidae as well as the Bagridae and Cichlidae in the Ethiopian region (Africa) (Section 4.3.1) (see Paperna, 1969, 1973, 1979; Paperna & Thurston, 1968).

There are some monogenean genera which are restricted to a particular catfish host species: for example: *Mizelleus* is thus far only found on the *Wallago attu* (Siluridae) of India and Thailand.

4.3.4.2 At species level

This study shows that the majority of monogenean species (63 species or 76 %) are restricted to one fish host species, while 16 species (19 %) have two host species (Table 4.11). Only four species (5 %) have more than two host species, example, *Quadriacanthus kobiensis* on four *Clarias* species and *Bychowskyella tchangi* on two *Clarias* species and on *Heteropneustes fossilis* (Heteropnuestidae), *Thaparocleidus caecus* is the most common species and could be found on six pangasiid host species belonging to four genera, viz., *Helicophagus waandersii*, *Pangasianodon hypophthalmus*, *Pangasius conchophilus*, *P. krempfi*, *P. larnaudii* and *Pteropangasius pleurotaenia* (Table 4.1 & Appendix 3.4). Besides *T. caecus*, there are six other *Thaparocleidus* species which could also be found on more than one pangasiid species, as exemplified by *Thaparocleidus* n. sp. 16 on *P. conchophilus* and *H. waandersii*, *Thaparocleidus* n. sp. 17 on *P. bocourti*, *P. krempfi* as well as *H. waandersii* (Table 4.1 & Appendix 3.4).

The fish species from different families in the same region can be found to be infected with the same monogenean species, for example *C. batrachus* (Clariidae) and *H. fossilis* (Heteropneustidae) share the same *Bychowskyella* species (*B. tchangi*).

A similar pattern is observed in Peninsular Malaysia and India. Of the 36 monogenean species on Malayan freshwater catfish, 33 species (91 %) are mono-specific (see Lim, 1987a). In India all the 76 monogenean species (100 %) from catfish are monospecific. High specificity is also observed on freshwater African catfish. Eighty percent (28 species) of the known African monogenean species are restricted to a single fish host species (see Appendix 1).

Table 4.11 Host distribution patterns of monogenean species

Monogenean genera	No. of monogenean species on fish host						Total
	on 1 host	on 2 hosts	on 3 hosts	on 4 hosts	on 5 hosts	on 6 hosts	
Bifurcohaptor	2	-	-	-	-	-	2
Bychowskyella	6	1	1	-	-	-	8
Cornudiscoides	8	5	-	-	-	-	13
Hamatopeduncularia	1	1	-	-	-	-	2
Mizelleus	1	-	-	-	-	-	1
Quadriacanthus	-	1	-	1	-	-	2
Thaparocleidus	45	8	1	-	-	1	55
Total no. of monogenean species	63	16	2	1	0	1	83
Percentage (%)	76	19	3	1	0	1	100

This study confirms the specificity of the majority of monogeneans, this is especially true for the monogeneans of the bagrids where there are no common monogenean species amongst the bagrids, unlike the pangasiids which have several common monogeneans (see Section 4.2.5).

4.3.5. Biogeographical distribution of monogeneans

A tolal of 225 monogenean species from 21 genera (16 freshwater monogenean genera and five marine genera) have been reported on the Old World siluriforms and are summarised in Table 4.12 & 4.13 (see Appendix 1). Of these, 175 monogenean species (78 %) are from 56 Old World freshwater catfish species (26 fish genera and nine families) (see Appendix 1). The 21 genera include *Anchylodiscus* Johnston & Tiegs, 1922, *Ancylodiscoides* Yamaguti, 1937, *Ancyrocephalus* Creplin, 1939, *Bagrobdella* Paperna, 1969, *Bifurcohaptor* Jain, 1958, *Bychowskyella* Achmerow, 1952, *Chauhanellus* Bychowsky & Nagibina,

Table 4.12 Number of described monogenean species of the Old World catfishes from different regions
(fw = freshwater species; m = marine species)

Monogenean genera	Regions													
	Africa		Australia		Indian subcontinent		Indo-China		Peninsular Malaysia		Palearctic		Thailand	
	fw	m	fw	m	fw	m	fw	m	fw	m	fw	m	fw	m
Anchylodiscus Johnston & Tiegs, 1922	-	-	1	1	-	-	-	-	-	2	-	-	-	-
Ancylodiscoides Yamaguti, 1937	-	-	-	-	1	-	4	-	-	-	1	-	-	-
Ancyrocephalus Creplin, 1839	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Bagrobdella Paperna, 1969	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Bifurcohaptor Jain, 1958	-	-	-	-	6	-	-	-	1	-	-	-	-	-
Bychowskyella Achmerow, 1952	-	-	-	-	16	-	5	-	4	-	1	-	1	-
Chauhanellus Bychowsky & Nagibina, 1969	-	1	-	2	-	3	-	2	-	12	-	-	-	-
Cornudiscoides Kulkarni, 1969	-	-	-	-	8	-	-	-	6	-	-	-	-	-
Gyrodactylus Nordmann, 1832	2	-	-	-	2	-	1	-	1	-	1	-	-	-
Hamatopeduncularia Yamaguti, 1953	-	4	-	5	3	3	-	5	-	11	-	-	-	-
Macrogyrodactylus Malmberg, 1957	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Neocalceostoma Tripathi, 1957	-	-	-	-	1	1	-	-	-	1	-	-	-	-
Neocalceostomides Kritsky, Mizelle & Bilqees, 1978	-	-	-	1	-	1	-	-	-	3	-	-	-	-
Mizelleus Jain, 1957	-	-	-	-	5	-	-	-	-	-	-	-	1	-
Paraquadriacanthus Ergens, 1988	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Protoancylodiscoides Paperna, 1969	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudancylodiscoides Yamaguti, 1963	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Quadriacanthus Paperna, 1961	8	-	-	-	1	-	2	-	1	-	-	-	2	-
Schilbetrema Paperna & Thurston, 1968	12	-	-	-	-	-	-	-	-	-	-	-	-	-
Schilbetrematoides Kritsky & Kulo, 1992	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Thaparocleidus Jain, 1952	-	-	-	-	33	-	8	-	7	-	29	-	2	-
Total	30	5	1	9	76	8	20	7	20	29	33	-	6	-
Grand total	35		10		84		27		49		33		6	

Table 4.13 Diversity of monogenean genera on various catfish families in different regions (including this study)

(No. of monogenean species in parentheses; * marine catfish families; ** unpublished data)

Fish families	Regions						
	Ethiopian (Africa)	Australian	Indian subcontinent	Peninsular Malaysia	Thailand	South China & Indo-china	Palearctic & Amur-Chinese
Ariidae*	*Chauhanellus* (1) *Hamatopeduncularia* (4)	*Chauhanellus* (2) *Hamatopeduncularia* (5) *Neocalceostomoides* (1)	*Chauhanellus* (3) *Hamatopeduncularia* (3) *Neocalceostoma* (1) *Neocalceostomoides* (1)	*Chauhanellus* (12) *Hamatopeduncularia* (10) *Neocalceostoma* (1) *Neocalceostomoides* (3)	*Hamatopeduncularia* (2)	*Chauhanellus* (2) *Hamatopeduncularia* (5)	-
Bagridae	*Quadriacanthus* (1)	-	*Ancylodiscoides* (1) *Bifurcohaptor* (3) *Bychowskyella* (2) *Cornudiscoides* (8) *Hamatopeduncularia* (1) *Gyrodactylus* (1) *Thaparocleidus* (8)	***Bifurcohaptor* (3) ***Cornudiscoides* (8) ***Thaparocleidus* (8)	*Bifurcohaptor* (2) *Cornudiscoides* (13) *Thaparocleidus* (15)	*Ancylodiscoides* (4) *Bychowskyella* (1)	*Bychowskyella* (1) *Pseudancylodiscoides* (1) *Thaparocleidus* (3)
Clarioteidae	*Bagrobdella* (3) *Protoancylodiscoides* (1)	-	-	-	-	-	-
Clariidae	*Quadriacanthus* (8) *Paraquadriacanthus* (1) *Gyrodactylus* (2) *Macrogyrodactylus* (1)	-	*Bychowskyella* (1) *Quadriacanthus* (1)	*Bychowskyella* (2) *Quadriacanthus* (1) *Gyrodactylus* (1)	*Bychowskyella* (7) *Quadriacanthus* (2) *Gyrodactylus* (1)	*Bychowskyella* (3) *Quadriacanthus* (2) *Gyrodactylus* (1)	*Gyrodactylus* (1)

Table 4.13 cont'd

Fish families	Localities						
	Ethiopian (Africa)	Australian	Indian subcontinent	Peninsular Malaysia	Thailand	South China & Indo-china	Palearctic & Amur-Chinese
Heteropneustidae	-	-	*Bychowskyella* (1) *Gyrodactylus* (1)	-	*Bychowskyella* (1) *Gyrodactylus* (1)	-	
Mochocidae	*Ancyrocephalus* (1)	-	-	-	-	-	-
Pangasiidae	-	-	*Thaparocleidus* (1)	*Thaparocleidus* (2)	*Thaparocleidus*(19)	*Thaparocleidus* (1)	-
Plotosidae*	-	*Anchylodiscus* (2)	-	*Anchylodiscus* (2)	-	-	-
Schilbeidae	*Schilbetrema* (12) *Schilbetrematoides*(1)	-	*Bychowskyella* (8) *Thaparocleidus* (5)	-	*Thaparocleidus* (2)	-	-
Siluridae	-	-	*Bychowskyella* (3) *Mizelleus* (5) *Thaparocleidus* (19) *Hamatopeduncularia* (2) *Neocalceostoma* (1)	*Bychowskyella* (1) ***Thaparocleidus*(10)	*Mizelleus* (1) *Thaparocleidus*(18)	*Ancylodiscoides* (1) *Thaparocleidus* (6)	*Ancylodiscoides* (1) *Thaparocleidus* (26)
Sisoridae	-	-	*Bychowskyella* (1) *Bifurcohaptor* (3)	*Bychowskyella* (1)	*Bychowskyella* (1) *Thaparocleidus* (1)	*Bychowskyella* (1)	-
Total (freshwater/ marine)	35 (20/5)	10 (1/9)	84 (76/8)	65 (39/26)	83 (83/0)	27 (20/7)	33 (33/0)

1969, *Cornudiscoides* Kulkarni, 1969, *Gyrodactylus* Nordmann, 1832, *Hamatopeduncularia* Yamaguti, 1953, *Macrogyrodactylus* Malmbergs, 1957, *Mizelleus* Jain, 1957, *Neocalceostoma* Tripathi, 1957, *Neocalceostomoides* Kritsky, Mizelle & Bilqees, 1978, *Paraquadriacanthus* Ergens, 1988, *Protoancylodiscoides* Paperna, 1969, *Pseudancylodiscoides* Yamaguti, 1963, *Quadriacanthus* Paperna, 1961, *Schilbetrema* Paperna & Thurston, 1968, *Schilbetrematoides* Kritsky & Kulo, 1992 and *Thaparocleidus* Jain, 1952 (Table 4.12 & Appendix 1). The marine genera are *Anchylodiscus*, *Chauhanellus*, *Hamatopeduncularia*, *Neocalceostoma* and *Neocalceostomoides* (see Appendix 1). However *Hamatopeduncularia* could be found on freshwater ariids (Section 4.2.1). The Thai freshwater catfish harbour eight genera: *Bifurcohaptor*, *Bychowskyella*, *Cornudiscoides*, *Gyrodactylus*, *Mizelleus*, *Quadriacanthus*, *Thaparocleidus* and *Hamatopeduncularia* (a marine genus).

Species incorrectly identified as *Dactylogyrus* Diesing, 1850, and *Urocleidus* Mueller, 1934 from Indian freshwater siluriforms had been re-assigned to *Thaparocleidus* (see Lim, 1996b). The report of *Heteronchocleidus* Bychowsky, 1957 from *Wallago attu* should be re-examined because *Heteronchocleidus* is a monogenean of the anabantoids (see Lim & Lerssutthichawal, 1996). While *Dactylogyrus* is found mainly on the cyprinids and on Hemirhamphidae (see Lim, 1987a).

The monogenean genera and species from the different biogeographical regions are different (Table 4.12). Of the 16 monogenean genera recorded on the freshwater catfish, eight are present in the Oriental region, while nine are in Ethiopian region and five are in Palearctic region (Tables 4.12 & 4.13).

The monogenean genera found on the freshwater catfish within the different parts of the Oriental region are similar (Table 4.13). India, South China, Malaysia and Thailand share three monogenean genera, *Bychowskyella*, *Quadriacanthus* and *Thaparocleidus*. The other four genera seemed to be restricted to certain areas and habitats: *Ancylodiscoides* is found in Indian subcontinent and South China, *Bifurcohaptor* and *Cornudiscoides* in India, Malaysia and Thailand, and *Mizelleus* in India and Thailand. However, the three genera, *Hamatopeduncularia* *Heteronchocleidus* and *Neocalceostoma* recorded from the freshwater catfish from India could be errorneous (see Lim, 1996a; Lim & Lerssutthichawal, 1996).

Monogenean species diversity in different regions

Sixty-four percent (112 species) of the known freshwater monogeneans of Old World siluriforms (175 species) are from the siluriform fish of the Oriental region (see Appendix 1). Sixty-seven percent of the 112 Oriental monogenean species, that is 76 species, are from 18 Indian catfish species (Table 4.12), with 20 mnogenean species each from China and Peninsular Malaysia. India shares four monogenean species with Thailand, two species with Indo-China and South China and two species with Peninsular Malaysia (Table 4.14). Thailand and Malaysia have the same 13 monogenean species (Table 4.14). Of the 11 monogenean genera recorded from freshwater catfish in the Oriental region (including the present study) (Table 4.12), *Thaparocleidus* has the greatest diversity (102 species) which are distributed on 41 fish species in five families (Table 4.13 & Appendix 1). While *Bychowskyella* (with 28 species) are found to infect six host families (Table 4.7).

The Ethiopian region (Africa) possesses 30 monogenean species from nine genera (including *Gyrodactylus* and *Macrogryodactylus*). Six of the seven genera are endemic to Ethiopian region, *Bagrobdella* (three species) and *Protoancylodiscoides* (one species) from the Claroteidae (formerly Bagridae), *Macrogyrodactylus* (one species) and *Paraquadriacanthus* (one species) from the Clariidae, *Schilbetrema* (12 species) and *Schilbetrematoides* (one species) from the Schilbeidae, whilst five monogenean genera (33 species), *Ancylodiscoides*, (one species), *Bychowskyella* (one species), *Pseudancylodiscoides* (one species), *Thaparocleidus* (29 species) and *Gyrodactylus* (one species) were recorded from the Palearctic (Amur-Chinese regions) (Tables 4.12 & 4.13; Appendix 1). *Pseudancylodiscoides* is restricted to the bagrid of the Palearctic region.

Table 4.14 Distribution of known monogenean species on Thai catfish.

(A: Ariidae; B: Bagridae; C: Clariidae; H: Heteropneustidae; P: Pangasiidae; Si: Siluridae; Ss: Sisoridae)

Monogenean species	Fish host species	Localities				
		Thailand	Malaysia	India	Indo-China	Africa
Bifurcohaptor baungi Lim & Furtado, 1983	*Hemibagrus nemurus* (B)	+	+	-	-	-
Bychowskyella sisoris Lim, 1991	*Glyptothorax major* (Ss)	+	+	-	-	-
Bychowskyella tchangi Gussev, 1976	*Clarias batrachus* (C)	+	+	+	+	-
Cornudiscoides anchoratus Lim, 1987	*Mystus nigriceps* (B)	-	+	-	-	-
	M. singaringan (B)	+	-	-	-	-
C. bagri Lim, 1987	*M. nigriceps*	-	+	-	-	-
	M. singaringan	+	-	-	-	-
C. facicirrus Lim, 1987	*M. nigriceps*	-	+	-	-	-
	M. singaringan	+	-	-	-	-
C. germinus Gussev, 1976	*M. vittatus* (B)	-	-	+	-	-
	M. mysticetus (B)	+	-	-	-	-
C. malayensis Lim, 1987	*Hemibagrus nemurus*	+	+	-	-	-
C. selangoricus Lim, 1987	*H. nemurus*	+	+	-	-	-
C. sundanensis Lim, 1987	*H. nemurus*	+	+	-	-	-
Hamatopeduncularia longicopulatrix Lim, 1996	*Arius venosus* (A)	-	+	-	-	-
	Hemipimelodus borneensis (A)	+	-	-	-	-
Quadriacanthus bagrae Paperna, 1979	*Bagrus docmac* (B)	-	-	-	-	+
	Clarias gariepinus (C)	+	-	-	-	+
	Clarias hybrid	+	-	-	-	-
Q. kobiensis Ha, 1968	*C. fuscus* (C)	-	-	-	+	-
	C. batrachus	+	+	+	-	-
	C. macrocephalus (C)	+	-	-	-	-
	C. cataractus (C)	+	-	-	-	-
	C. meladerma (C)	+	-	-	-	-
Thaparocleidus caecus (Mizelle & Kritsky,1969) Lim, 1996	*Pangasianodon hypophthalmus* (P)	+	+	-	-	-
	Helicophagus waandersii (P)	+	-	-	-	-
	Pangasius conchophilus (P)	+	-	-	-	-
	P. krempfi (P)	+	-	-	-	-
	P. larnaudii (P)	+	-	-	-	-
	Pteropangasius pleurotaenia (P)	+	-	-	-	-
T. siamensis (Lim, 1990) Lim, 1996	*Pangasianodon hypophthalmus*	+	+	-	-	-
T. indicus (Kulkarni, 1969) Lim, 1996	*Wallago attu* (Si)	+	-	-	-	-

4.4 Summary

Previous investigations on monogeneans have shown that the majority of monogeneans are restricted to a particular host species (host-specific) (Llewellyn, 1956; Gussev, 1976; Kennedy, 1975; Rohde, 1979). This is also shown to be true of the monogeneans on the Thai siluriform fishes where 76 % of the monogeneans are found on one host species (Section 4.3.4.2). The most quoted reason for host-specificity is the co-evolution of the monogeneans with their hosts (see Brooks, 1989; Lim, 1987a). However, there are also some species that have wide specificity and can be found on a number of related as well as unrelated fish host species in the tropics (see Lim, 1987a; Lim & Furtado, 1986). This is shown by 24 % of the monogenean species from the monogeneans on the Thai catfish: for example *T. ceacus* are found on six species of pangasiids while *H. longicopulatrix* is found on both marine and freshwater ariids of Peninsular Malaysia and Thailand, respectively (Section 4.3.1). A possible explanation for the presence of a particular monogenean species on unrelated hosts is the ability of this species to adopt and overcome host immune system. This phenomenon is known as host-capture or host-transfer (see Lim, 1987a).

On a larger scale (see Section 4.3.5) some groups of monogeneans have shown to be restricted to a particular macro-environment within a given biogeographical region (Gussev, 1976; Lim, 1987a) as exemplified by the presence of *Mizelleus* in India and Thailand (Section 4.3.1) and not in Peninsular Malaysia. Analyses of the global distribution pattern of the monogeneans reveal that monogeneans are usually restricted to biogeographical regions (Gussev, 1976; Lim, 1987a). This is indicated by the difference in monogenean genera on the catfish of Africa and Southeast Asia (Section 4.3.5). However, there are some monogeneans which are found on related hosts in apparently unconnected faunistic regions; for example *Quadriacanthus* is found on African, India and Southeast Asian clariids (Section 4.2.3), suggesting some affinities between these different biogeographical regions (Lim, 1997, 1998; Paperna, 1979). A comparative analysis of the monogenean fauna on the Thai freshwater siluriforms reveal that the Thai monogeneans are related to those of India, South China and Peninsular Malaysia and Africa (Section 4.3.5).

The species richness on each siluriform host species vary from one to eight (Section 4.3.3.1). The absence of monogeneans on some host species (*Bagrichthys macropterus* (Bagridae), *Hemibagrus wyckii* (Bagridae), *Pangasianodon gigas* (Pangasiidae) and *Bagarius yarrelli* (Sisoridae) (Section 4.2) might be apparent due to the survey of too few host species and localities. Ninety-four percent of the monogeneans are co-existing species on 72 % of infected fish species. The co-existing species can be of the same genus (congeners) or belong to different genera. For example on the bagrids, *H. nemurus* habours *Bifurcohaptor* (two species), *Cornudiscoides* (three species)and *Thaparcoleidus* (three species), while *P. larnaudii* on the other hand is host to six species of *Thaparocleidus* (Section 4.3.3.2).