CHAPTER 3
THE SILURIFORMES OF THAILAND

3.1 Introduction

The background information on the freshwater siluriform fishes of Thailand are provided in this Chapter. The information include the diversity, distribution pattern, taxonomic status, phylogenetic relationships and evolutionary history of the siluriforms examined for monogeneans in the course of this study. Knowledge of the hosts is necessary to elucidate monogenean host associations. Proper identification of fishes is important since incorrect identifications will result in erroneous results regarding host-parasite specificity.

3.2 The Siluriformes

Siluriform fishes are distributed in all continents, except in the Antarctica only fossil catfish were found (Kobayakawa, 1991; Nelson, 1984, 1994). More than 50 % of the siluriforms species (1,300 species in 14 families) are present in South America (Neotropical region), while approximately 350 species in eight families are found in Africa (Ethiopian region) and about 400 species in 13 families are found in the Oriental region (Kobayagawa, 1991; Mo, 1991). However only 14 species of Siluridae are recorded in the Palearctic region (Europe and East Asia) (see Kobayakawa, 1989). Siluriformes are mainly found in freshwater systems with two families in marine and brackish water, Ariidae and Plotosidae, which could be found in freshwater (see Section 3.5.1).

3.3 The freshwater siluriforms of Thailand

3.3.1 Classification

Smith (1945) estimated there were a total of 560 freshwater fish species in the 209 genera and 49 families in Thailand, while in 1981 Suvatti noted about 570 freshwater fish species from 190 genera and 55 families.

The classification of the Siluriformes or catfish is still unsettled. In fact the number of species, genera and families vary according to authors and era. For instance, in 1984 Nelson recognised 31 families, 400 genera and 2,211 species, while in 1994 he recognised 34 families, 412 genera and 2,405 species in the order Siluriformes, while Mo (1991) proposed 35 families. The sister group of siluriforms is the gymnotiforms (Nelson, 1994).

Cypriniformes (or Eventognathi) is the largest order with 46 % (255 species) of the freshwater fish species in Thailand. According to Smith (1945) the order Siluriformes (Nematognathi) is the second largest fish order with 94 species which make up 17 % of the freshwater fish fauna in Thailand. There are still disagreement on the interrelationships of the families (see later Section 3.4).

In this study the familial classification of Mo (1991) is followed, while other references were used for the different genera and species (see Bornbusch, 1995; Kobayakawa, 1989; Kottelat, 1989; Kottelat, Whitten, Kartikasari & Wirjoatmodjo, 1993; Mo, 1991; Roberts, 1989; Smith, 1945; Vidthayanon & Roongthongbaisuree, 1993).

There are still many unresolved taxonomic issues (generic and species) concerning the siluriforms especially the freshwater groups, hence the taxonomic status of the members of the siluriforms are also constantly being revised and the species list altered (see Bornbusch, 1991, 1995; Bornbusch & Lundberg, 1989; Chen & Lundberg, 1994; Kobayakawa, 1989; Kottelat & Lim, 1995; Kottelat, Whitten, Kartikasari & Wirjoatmodjo, 1993; Mo, 1991; Ng, 1992; Ng & Kottelat, 1996, 1997; Ng & Lim, 1995; Ng & Ng, 1998; Roberts, 1982a, 1982b, 1983, 1989, 1992a, 1994; Roberts & Vidthayanon, 1991; Vidthayanon & Roongthongbaisuree, 1993). A recent catfish survey in Thailand showed 98 freshwater catfish species in 35 genera from 11 families (Vidthayanon; unpublished data) (Table 3.1).

There are several catfish species in Thailand which are now considered to be very rare, threatened or endangered (Vidthayanon, 1994). *Eutropiichthys vacha*, *Ceratoglanis scleronema*, *Kryptopterus limpok* and *Platytropius siamensis* have not been recorded since 1966 (Vidthayanon & Roongthongbaisuree, 1993). It is possible that these five species of catfish are either extinct or their populations are drastically reduced.

Table 3.1 List of freshwater catfish species in Thailand

(* no information; ** examined in this study)

Fish species	Distribution				
	North	Northeast	Central	East	South
Akysidae:					
Akysis armatus Vaillant, 1902	-	-	-	-	+
A. leucorhynchus Fowler, 1934	+	-	-	-	-
A. macronema Bleeker, 1860	-	-	-	+	+
A. maculipinnis Fowler, 1934	-	-	-	+	-
A. pictus Gunther, 1883	-	-	-	-	+
Amblycipitidae:					
Amblyceps mangois (Hamilton, 1822)	+	+	-	+	+
Ariidae:					
Hemipimelodus borneensis (Bleeker, 1851)**	-	-	+	-	-
H. bicolour Fowler, 1935	-	-	+	-	-
H. intermedius Vinciguerra, 1880	-	-	+	-	-
H. siamensis Sauvage, 1878	-	-	+	+	-
Bagridae:					
Aorichthys seenghala (Sykes, 1839)	+	-	+	-	-
Bagrichthys macropterus (Bleeker, 1853)**	-	-	+	-	-
B. macracanthus (Bleeker, 1854)	+	+	+	+	-
Bagroides melapterus Bleeker, 1851	+	-	+	-	-
Batasio tengara (Hamilton-Buchanan, 1822)**	-	-	+	-	+
Hemibagrus baramensis (Regan, 1906)	-	-	-	-	+
H. nemurus (Val. in Cuv. & Val., 1839)**	+	+	+	+	+
H. planiceps (Val. Cuv. & Val., 1839)	-	-	+	+	+
H. wyckii (Bleeker, 1858)**	+	+	+	-	+
H. wyckoides (Chaux & Fang, 1949)**	+	+	+	-	-
Leiocassis poecilopterus (Val., 1839)*					
Mystus albolineatus Roberts, 1994	+	+	+	+	-
M. atrifasciatus Fowler, 1937**	+	+	+	-	-
M. bocourti (Bleeker, 1864)**	+	+	+	-	-

Table 3.1 cont'd

Fish species	Distribution				
	North	Northeast	Central	East	South
M. gulio (Hamilton, 1822)**	-	-	+	+	+
M. micracanthus (Bleeker, 1846)	+	+	+	+	+
M. multiradiatus Roberts, 1992	+	+	+	-	-
M. mysticetus Roberts, 1992**	+	+	+	-	-
M. pulcher (Chaudhuri, 1911)	-	-	-	-	+
M. rhegma Fowler, 1935	+	+	+	-	-
M. singaringan (Bleeker, 1846)**	+	+	+	-	+
M. wolffii (Bleeker, 1851)**	-	-	+	+	+
Pseudomystus bicolor (Fowler, 1934)*					
P. siamensis (Regan, 1913)**	+	+	+	+	+
P. stenomus (Val. in Cuv. & Val., 1839)	-	-	+	+	+
Chacidae:					
Chaca bankanensis	-	-	-	-	+
Clariidae:					
Clarias batrachus (Linnaeus, 1758)**	+	+	+	+	+
C. cataractus (Fowler, 1939)**	-	-	-	-	+
C. leiacanthus Bleeker, 1851	-	-	+	-	-
C. macrocephalus Gunther, 1864**	+	+	+	+	+
C. meladerma Bleeker, 1847**	-	-	-	-	+
C. nieuhofi (Val. in Cuv. & Val., 1840)**	-	-	-	-	+
C. teysmanni (Bleeker, 1857)	-	-	-	-	+
Heteropneustidae:					
Heteropneustes fossilis (Bloch, 1797)**	+	+	+	-	+
Pangasiidae:					
Helicophagus waandersii Bleeker, 1858**	+	+	+	-	-
Pangasianodon gigas Chevey, 1930**	+	+	-	-	-
P. hypophthalmus (Sauvage, 1878)**	+	+	+	+	+

Table 3.1 cont'd

Fish species	Distribution				
	North	Northeast	Central	East	South
Pangasius bocourti Sauvage, 1880**	+	+	+	-	-
P. conchophilus Roberts & Vidthayanon, 1991**	+	+	+	-	-
P. krempfi Fang & Chaux, 1949**	-	+	-	-	-
P. larnaudii Bocourt, 1866**	-	+	+	-	-
P. macronema Bleeker, 1851**	+	+	+	-	-
P. polyuranodon Bleeker, 1852	-	-	+	+	-
P. sanitwongsei Smith, 1931**	-	+	+	-	-
Pteropangasius pleurotaenia (Sauvage, 1878)**	-	+	+	-	-
P. micronema (Bleeker, 1847)	-	+	+	-	-
Schilbeidae:					
Clupisoma platteri Hora, 1937	+	-	-	-	-
C. sinensis (Huang, 1981)	+	-	-	-	-
Eutropiichthys vacha (Hamilton, 1822)	+	-	-	+	-
Laides hexanema (Bleeker, 1852)**	+	+	+	-	-
Platytropius siamensis (Sauvage, 1883)	-	-	+	-	-
Siluridae:					
Belodontichthys dinema (Bleeker, 1851)**	+	+	+	-	-
Ceratoglanis scleronema (Bleeker, 1862)	-	-	+	-	-
Hemisilurus mekongensis Bornbusch & Lundberg, 1989**	+	+	-	-	-
Kryptopterus apogon (Bleeker, 1851)**	+	+	+	-	+
K. bicirrhis (Val. in Cuv & Val., 1839)**	-	-	-	-	-
K. bleekeri Gunther, 1864**	+	+	+	-	+
K. cheveyi Durand, 1940	+	+	+	-	-
K. cryptopterus (Bleeker, 1851)**	+	+	+	+	+
K. hexapterus (Bleeker, 1851)	+	-	+	-	-
K. limpok (Bleeker, 1851)	-	-	+	-	-
K. micronema (Bleeker, 1846)	-	-	+	-	-
K. moorei Smith, 1945	-	-	+	-	-

Table 3.1 cont'd

Fish species	Distribution				
	North	Northeast	Central	East	South
Ompok bimaculatus (Bloch, 1797)**	+	+	+	+	+
O. hypophthalmus (Bleeker, 1846)	-	-	+	-	+
O. krattensis (Fowler, 1934)	-	-	-	-	+
Silurichthys hasselti Bleeker, 1858	-	-	-	+	-
S. leucopodus Fowler, 1939	-	-	-	-	+
S. phaiosoma (Bleeker, 1851)	-	-	-	+	-
S. schneideri Volz, 1904	-	-	-	-	+
Silurus cochinchinensis (Val. in Cuv. & Val., 1839)	-	-	-	-	+
Silurus torrentis Kobayakawa, 1989	-	-	-	-	+
Wallago attu (Bloch & Schneider, 1802)**	+	+	+	-	-
W. leerii Bleeker, 1851	-	+	-	-	+
Sisoridae:					
Bagarius bagarius (Hamilton-Buchanan, 1823)**	+	+	+	-	+
B. suchus Roberts, 1983	-	+	-	-	-
B. *yarrelli* Sykes, 1841**	-	+	+	-	-
Gagata cenia (Hamilton, 1822)	+	-	+	-	-
Glyptothorax buchanani Smith, 1945	+	+	-	-	-
G. callopterus Smith, 1945	-	-	-	-	+
G. fuscus Fowler, 1934	-	-	-	+	+
G. major (Boulenger, 1894)**	+	-	+	-	+
G. lampris Fowler, 1934	+	-	-	-	-
G. laoensis Fowler, 1934	-	+	+	-	-
G. platypogonoides (Bleeker, 1855)	+	-	-	-	+
G. prashadi Mukerji, 1932	-	-	-	-	+
G. trilineatus Blyth, 1860	+	-	-	+	+
Oreoglanis siamensis Smith, 1933	+	-	-	-	-
Total	**47**	**43**	**59**	**21**	**43**

Currently the taxonomy of the catfish is based on morphology and the phylogenetic relationships of the catfish are also based on morphology (see later). Although presently molecular techniques are used to distinguish between several species of catfish of the family Pangasiidae (Pariselle, pers. com.).

3.3.2 Freshwater siluriforms investigated

Of the ten catfish families in Thailand recognised by Smith (1945), eight families are freshwater, while the other two families are considered to be marine. The ten freshwater families are Akysidae (with one genus), Amblycipitidae (with one genus), Bagridae (with four genera), Clariidae (with two genera), **Heteropneustidae** (with one genus), Schilbeidae (with seven genera), Siluridae (with eight genera) and Sisoridae (with four genera) (see Smith, 1945). The marine catfish families are the Ariidae (or Tachysuridae) (with five genera) and Plotosidae (with one genus) (see also Smith, 1945). There are however four species of freshwater ariids in Thailand; *Hemipimelodus borneensis*, *H. bicolor*, *H. intermedius* and *H. siamensis*.

Only 44 species from 21 genera and eight families out of 98 freshwater siluriform species (35 genera and 11 families) recorded in Thailand (Vidthayanon, unpublished data) were examined for monogeneans in this study. This means that less than 50 % of the recorded Thai catfish species were examined. A total of 335 specimens of catfish were examined (Table 3.2) and of these, 263 specimens belonging to 40 catfish species were infected with monogeneans (Table 3.2). A total of 83 species of monogeneans were collected (Chapter 4). The distribution patterns of the different monogeneans on these fish species will be discussed in Chapter 4.

3.3.2.1 Akysidae

Akysidae is endemic to Southeast Asia (Alfred, 1966). The fish species in this family are diminutive. This family consists of four genera, viz., *Acrochordonichthys* Bleeker, 1858 (with four species), *Akysis* Bleeker, 1858 (with 12 species), *Parakysis* Herre, 1940 (with four species) and *Breitensteinia* Steindachner, 1881 (with three species) (see Ng & Kottelat, 1996; Ng & Lim, 1995; Ng & Siebert, 1998; Roberts, 1989). Although Roberts (1989) proposed the family Parakysidae to accommodate the genus *Parakysis*, but *Parakysis* is still considered to be in the

Akysidae by Mo (1991) and Ng and Lim (1995). Herein Mo's classification is accepted. There are five species of *Akysis* in Thailand: *Akysis armatus* Vaillant, 1902, *A. leucorhynchus* Fowler, 1934, *A. maculipinnis* Fowler, 1934, ***A. macronemus*** Bleeker, 1860 and *A. pictus* Gunther, 1883 (see Smith, 1945; Suvatti, 1981). No *Akysis* species was examined in this investigation. Thus far no monogeneans are recorded from this family, hence the phylogenetic relationships of the members of this family will not be considered.

3.3.2.2 Amblycipitidae

There are three genera in the Amblycipitidae: *Amblyceps* Blyth, 1858 (with four species), *Liobagrus* Hilgendorf, 1878 (with one species) and *Xiurenbagrus* Chen & Lundberg, 1994 (with one species). *Liobagrus* and *Xiurenbagrus* are restricted to South China, while *Amblyceps* is distributed mainly in the Indian subcontinent to Thailand (Chen & Lundberg, 1994). *Amblyceps mangois* (Hamilton, 1822) is the only species recorded in Thailand, but this species was not examined in this study.

3.3.2.3 Ariidae

In Thailand there are five genera in the Ariidae: *Arius* Valenciennes, 1840, *Osteogeneiosus* Bleeker, 1846, *Batrachocephalus* Bleeker, 1846, *Ketengus* Bleeker, 1847 and *Hemipimelodus* Bleeker, 1858. The Ariidae or Tachysuridae are primarily marine or brackish water catfish with four marine genera (*Arius*, *Osteogeneiosus*, *Batrachocephalus* and *Ketengus*) and one freshwater genus (*Hemipimelodus*).

There are four species of *Hemipimelodus* in Thailand: *Hemipimelodus bicolor* Fowler, 1935, *Hemipimelodus borneensis* (Bleeker, 1851), *Hemipimelodus intermedius* Vinciguerra, 1880 and *Hemipimelodus siamensis* Sauvage, 1878. Only *H. borneensis* (five individuals) were examined and found to be infected with monogeneans (see Section 4.2.1). The marine ariids are not considered in this study because it is outside the scope of this investigation and besides the Ariidae has been studied by Lim (1994, 1995a, 1996a) in the coastal waters of Peninsular Malaysia. There are no information concerning the phylogenetic relationships of the ariid species, except that the Ariidae is a monophyletic group (Mo, 1991; Vidthayanon, pers. com.)

3.3.2.4 Bagridae

The Bagridae could be found in tropical Africa and Asia. There are 15 genera of bagrids in Asia, of which nine genera are distributed in Southeast Asia. In Thailand there are eight genera with 25 recorded species: *Aorichthys* Wu, 1939 (one species), *Bagrichthys* Bleeker, 1858 (two species), *Bagroides* Bleeker, 1851 (one species), *Batasio* Blyth, 1860 (one species), *Hemibagrus* Bleeker, 1862, (five species), *Mystus* Scopoli (11 species), *Leiocassis* Bleeker, 1858 (one species) and *Pseudomystus* Jayaram, 1968 (three species) (see Mo, 1991; Roberts, 1989, 1992a, 1994) (Table 3.1). In this study only five genera of bagrids: *Bagrichthys*, *Batasio*, *Hemibagrus*, *Mystus*, and *Pseudomystus* were examined (Table 3.2).

Aorichthys Wu, 1939

Mo (1991) recently reassigned the two fish species, *Mystus aor* (Hamilton, 1822) and *Mystus seenghala* (Sykes, 1839) to the genus *Aorichthys*, and are now known as *Aorichthys aor* (Hamilton, 1822) and *A. seenghala* (Sykes, 1839), respectively. *Aorichthys aor* is found in India, Myanmar and Nepal, while *A. seenghala* is found in India, Nepal and in the Salween River at the border of Thailand and Myanmar. This genus was not examined for monogeneans. However monogeneans have been recorded from the two *Aorichthys* species from India (see Appendix 3.2: Monogeneans of Bagridae).

Bagrichthys Bleeker, 1858

There are four species of *Bagrichthys* Bleeker, 1858 restricted to Southeast Asia (Borneo, Sumatra, Thailand and Cambodia) (Mo, 1991). *Bagrichthys macropterus* (Bleeker, 1853) and *Bagrichthys macracanthus* (Bleeker, 1854) are present in Thailand, while *Bagrichthys macranodus* Roberts, 1989 and *Bagrichthys hypselopterus* (Bleeker, 1852) are restricted to Borneo and Sumatra (Kottelat *et al.*, 1993; Mo, 1991; Roberts, 1989). In this investigation only *B. macropterus* (five individuals) was examined for monogeneans but no monogenean was found.

***Bagroides* Bleeker, 1851**

Bagroides Bleeker, 1851 differs from the other bagrids in possessing serrated teeth in the dorsal spine. *Bagroides melapterus* Bleeker, 1851 is the only species of the *Bagroides* reported and is found in Thailand, Sumatra and Borneo (Mo, 1991; Roberts, 1989). No specimens of this fish species could be obtained during the course of this study.

***Batasio* Blyth, 1860**

Batasio tengara (Hamilton, 1822) (syn. *Mystus stigmaturus* Fowler, 1939 and *Mystus havmolleri* Smith, 1945) is the only species of the genus *Batasio* in Thailand. This species is distributed in India, Bangladesh, Myanmar, Thailand and Malaysia (see Kottelat, 1989; Mo, 1991). Only one specimen of *B. tengara* was examined and found to be infected with one monogenean species (Section 4.2.2).

***Hemibagrus* Bleeker, 1862**

Hemibagrus Bleeker, 1862 was previously considered a synonym of *Mystus* by many authors (see Kottelat, 1989; Mohsin & Ambak, 1983; Smith, 1945; Suvatti, 1981; Roberts, 1989). However, Mo (1991) reassigned five species of Thai *Mystus* (*Mystus baramensis* (Regan, 1906), *Mystus nemurus* (Val. in Cuv. & Val., 1893), *Mystus planiceps* (Val. in Cuv. & Val., 1839), *Mystus wyckoides* Chaux & Fang, 1949 and *Mystus wyckii* (Bleeker, 1858)) into the genus *Hemibagrus*. *Hemibagrus nemurus* and *Hemibagrus wyckii* are widely distributed in Thailand, Borneo, Sumatra and Peninsular Malaysia (see Mo, 1991; Mohsin & Ambak, 1983; Roberts, 1989). In Thailand both *H. nemurus* and *H. wyckoides* are successfully bred for culture (see Section 1.4) and *H. wyckii* is the next species targeted for intensive culture.

In this study *H. nemurus* (42 specimens), *H. wyckoides* (12 specimens) and *H. wyckii* (six specimens) were examined. Except for *H. wyckii*, the other two fish species were found to be infected with monogeneans (Section 4.2.2).

***Mystus* Scopoli, 1777**

There are now 11 valid species in the genus *Mystus* Scopoli, 1777 in Thailand (Table 3.1). The Thai *Mystus cavasius* (Hamilton-Buchanan, 1822) and

Pangasianodon gigas Chevey, 1930 are important cultured species (Vidthayanon & Roongthongbaisuree, 1993). *Pangasius krempfi* Fang & Chaux, 1949, *Pangasius macronema* Bleeker, 1851, *Helicophagus waandersii* Bleeker, 1858, *Pteropangasius pleuro-taenia* (Sauvage, 1878) as well as the six species mentioned above were examined for monogeneans (Table 3.2). Except for *P. gigas*, the other nine pangasiid species were found to harbour monogeneans (Section 4.2.5). The two species not examined are *Pangasius polyuranodon* Bleeker, 1852 and *Pteropangasius micronema* (Bleeker, 1847). *Pangasius polyuranodon* was examined prior to this investigation and monogeneans were found (Lim, pers. com.)

3.3.2.9 Schilbeidae

There are 16 genera and 40 species of Schilbeidae in the world (Nelson, 1984, 1994; Roberts, 1989). Schilbeid fishes are present in both Africa and Asia (Jubb, 1967; Kobayakawa, 1991; Nelson, 1984, 1994). However, Africa and Asia possess different schilbeid species. *Ailichthys*, *Eutropiellus*, *Eutropius*, *Schilbe*, *Schilbeichthys*, *Paraailia* and *Physalia* are restricted to Africa, while *Ailia*, *Clupisoma*, *Eutropiichthys*, *Laides*, *Platytropius*, *Pseudeutropius*, *Silonia*, *Silundia* and *Siluranodon* are restricted to Asia (see Jubb, 1967; Mo, 1991; Nelson, 1984, 1994; Roberts, 1989; Shrestha, 1994; Vidthayanon & Roongthongbaisuree, 1993).

Of the 16 genera, only five genera are found in Southeast Asia: *Clupisoma* Swainson, 1838, *Eutropiichthys* Bleeker, 1862, *Laides* Jordan, 1919, *Platytropius* Hora, 1937 and *Pseudeutropius* Bleeker, 1862 (see Roberts, 1989; Vidthayanon & Roongthongbaisuree, 1993). Except for *Pseudeutropius*, the other four genera are present in Thailand: *Platytropius siamensis* (Sauvage, 1883), *Laides hexanema* (Bleeker, 1852), *Eutropiichthys vacha* (Hamilton, 1822), *Clupisoma platteri* Hora, 1937 and *Clupisoma sinensis* (Huang, 1981) (Table 3.1). The schilbeids are however rare in Thailand and only *L. hexanema* was examined and found to be infected with monogeneans (Section 4.2.6).

3.3.2.10 Siluridae

Smith (1945) recorded nine genera of Siluridae in Thailand: *Wallagonia* Myers, 1938, *Kryptopterus* Bleeker, 1858, *Ompok* Bleeker, 1856, *Hemisilurus*

Bleeker, 1858, *Parasilurus* Bleeker, 1862, *Silurodes* Bleeker, 1858 and *Ceratoglanis* Myers, 1938. A recent revision of this family resulted in the following changes: *Parasilurus* is now considered a synonym of *Silurus* Linnaeus, 1758; *Silurodes* is a synonym of *Ompok* Lacepede, 1803; *Wallagonia* a synonym of *Wallago* Bleeker, 1851 (see Bornbusch, 1995; Kobayakawa, 1989; Roberts, 1982b).

Presently, there are 23 silurid species belonging to nine genera in Thailand, viz., *Belodontichthys* (one species), *Ceratoglanis* (one species), *Hemisilurus* (one species), *Kryptopterus* (nine species), *Ompok* (three species), *Silurichthys* (four species), *Silurus* (two species) and *Wallago* (two species) (Table 3.1). *Ceratoglanis scleronema* is classified as being very rare to endangered (Vidthayanon, 1994). Like the bagrids, clariids and pangasiids, the silurids are also economically important. At least four species have been successfully bred and cultured (see Section 1.4).

In this study only nine species from six genera are examined for monogeneans: *Belodontichthys dinema* Bleeker, 1851, *Hemisilurus mekongensis* Bornbusch & Lundberg, 1989, *Kryptopterus apogon* (Bleeker, 1851), *Kryptopterus bicirrhis* (Val. in Cuv. & Val., 1839), *Kryptopterus bleekeri* Gunther, 1864, *Kryptopterus cryptopterus* (Bleeker, 1851), *Ompok bimaculatus* (Bloch, 1797), *Wallago attu* (Bloch & Schneider, 1802) and *Silurichthys* sp. All the nine species were found to be infected with monogeneans (Table 3.2) (Section 4.2.7).

3.3.2.11 Sisoridae

There are 17 genera within the Sisoridae and all of them are restricted to Asia (Roberts, 1989). In the Indian subcontinent there are 63 sisorid species from 17 genera (Jayaram, 1981; Shrestha, 1994). There are 14 species of Sisoridae belonging to four genera in the Sisoridae in Thailand: *Bagarius* Bleeker, 1853 (with three species), *Glyptothorax* Blyth, 1860 (with nine species), *Gagata* Bleeker, 1858 (with one species) and *Oreoglanis* Smith, 1933 (with one species) (Smith, 1945; Roberts, 1983; Kottelat, 1989) (Table 3.1). In this study only three sisorid species, *Bagarius bagarius* (Hamilton-Buchanan, 1823), *Bagarius yarrelli* Sykes, 1841 and *Glyptothorax major* (Boulenger, 1894) were examined for monogeneans (Table 3.2), and only *B. yarrelli* was found to be uninfected (Section 4.2.8).

Table 3.2 Thai freshwater siluriform examined in the present study (* introduced species; ** hybridization)

Fish species	No. of fish examined	No. of infected fish
Akysidae	0	0
Amblycipitidae:	0	0
Ariidae:		
Hemipimelodus borneensis	5	4
Bagridae:		
B. macropterus	5	0
Batasio tengara	1	1
H. nemurus	42	33
H. wyckii	6	0
H. wyckoides	12	11
M. atrifasciatus	4	4
M. bocourti	5	4
M. gulio	3	3
M. mysticetus	1	1
M. singaringan	9	8
M. wolffii	6	6
Pseudomystus siamenesis	9	8
Chacidae:		
Clariidae:		
Clarias batrachus	12	11
C. cataractus	5	4
C. macrocephalus	16	10
C. meladerma	4	4
C. nieuhofi	11	7
C. gariepinus *	4	2
Clarias hybrid **	27	16
Heteropneustidae:		
Heteropneustes fossilis	10	7

Table 3.2 cont'd

Fish species	No. of fish examined	No. of infected fish
Pangasiidae:		
Helicophagus waandersii	7	7
Pangasianodon_gigas	7	0
P. hypophthalmus	9	9
Pangasius bocourti	8	7
P. conchophilus	10	10
P. krempfi	2	2
P. larnaudii	4	4
P. macronema	11	11
P. sanitwongsei	2	1
Pteropangasius pleurotaenia	7	7
Schilbeidae:		
Laides hexanema	4	4
Siluridae:		
Belodontichthys dinema	4	4
Hemisilurus mekongensis	1	1
Kryptopterus apogon	5	3
K. bicirrhis	2	2
K. bleekeri	9	8
K. cryptopterus	6	6
Ompok bimaculatus	22	20
Silurichthys sp.	3	2
Wallago attu	5	5
Sisoridae:		
Bagarius bagarius	6	2
B. yarrelli	2	0
Glyptothorax major	2	2
Total 44 species	335	263

3.4 Phylogenetic relationships of Thai catfish

This aspect is important to understand the phylogenetic relationships of monogeneans because the monogeneans co-evolve with their hosts (Brooks, 1979, 1986, 1989; Rohde, 1993) as indicated by the specificity of monogenean species. However it should be noted that in most cases the phylogenetic relationships of the fish are either incomplete or still unknown (Nelson, 1984, 1994).

Current phylogenetic relationships of the different fish groups including siluriforms have been postulated based on osteological structures. The newer taxonomic tool based on molecular biology will provide another character state which might together contribute to the construction of a more natural phylogenetic tree. Presently such approach has been undertaken by ORSTOM researchers to determine the relationships of pangasiid species in Southeast Asia (Pariselle, pers. com.).

The relationships of the Siluriformes in relation to the other fish orders have been postulated by a number of authors, viz., Berg (1947), Fink and Fink (1981), Mo (1991), Nelson (1984, 1994), Novacek and Marshall (1976) and Regan (1911).

Siluriformes together with Cypriniformes and Characiformes were postulated to evolve from ostariophysan ancestors during the Jurassic just before the break up of Gondwana (see Fink & Fink, 1981). Fink and Fink (1981) considered the Cypriniformes to be the most primitive group in the superorder Ostariophysi giving rise to Characiformes and Siluriformes. Fink and Fink's hypothesis is controversial to the hypothesis of Novacek and Marshall (1976) who considered the Siluriformes to be more primitive than the Cypriniformes. Fink and Fink's hypothesis seemed to concur with that of Darlington (1966) (Table 3.3). Nelson (1994) considered the gymnotiforms the sister-group of the siluriforms.

3.4.1 Familial relationships

The phylogenetic relationships of different families of the Siluriformes have also been proposed based on osteological features (Regan, 1911; Berg, 1947; Chardon, 1968) (see Table 3.3). Families sharing characters and features of fossil fishes could be assumed to be primitive. Diplomystidae is regarded as the

Table 3.3 The major hypotheses of fish evolution

Authors	concepts
Regan (1911)	Ostariophisi is the ancestor of Siluriformes. Based on the comparative anatomy, Diplomystidae is the most primitive fish group in the Siluriformes, followed by Ariidae and Siluridae
Berg (1947)	The use of Weberian apparatus in classification of the fish group. The phylogenetic relationships as in Regan (1911)
Darlington (1966)	Characiformes was first derived from Ostariophysi which evolved in the tropical sea (South East Asia). Characiform fish then gave rise to Siluriformes and dispersed to North and South America
Chardon (1968)	The use of Weberian apparatus in classification of the fish group. There are 3 levels of catfish I. Diplomystidae, II. Silurid group, III. Bagrid group with a transition group (Malapteruridae) between groups II and III
Novacek and Marshall (1976)	Ostariophysi was divided into 3 suborders: Gonorhynchiformes, Cypriniformes and Siluriformes. Siluriformes is older than Cypriniformes. Gymnotoidea is superfamily in suborder Cyprinoidei
Fink and Fink (1981)	Ostariophysi is divided into 4 orders, Gonorhynchiformes, Cypriniformes, Characiformes and Siluriformes. Characiformes and Cypriniformes are older than Siluriformes. Gymnotoidea is suborder in the Siluriformes
Mo (1991)	Based on 114 osteological features, Diplomystidae is the most primitive group, followed by Silridae, while Bagridae and Ariidae are considered as the advanced groups

most primitive siluriform family by many ichthyologists because the fish of this family has simple Weberian apparatus and possesses other characteristics of the ancestral catfish (ie. superficial dermal bone, teeth on maxillary bone, dermo-palatine, large otolith and pineal foramen) (see Berg, 1947, 1965; Chardon, 1968; Mo, 1991; Kobayakawa, 1991; Regan, 1911).

Both Regan (1911) and Berg (1947) considered the Ariidae and Doradidae as the next most primitive fish groups, followed by the Siluridae, Plotosidae and Bagridae. According to Regan (1911) and Berg (1947), the air-breathing fish group (Clariidae and Heteropneustidae) is recognised as the most advanced group within the Asian catfish groups.

Recently, Mo (1991) proposed a hypothesis which contradicts to the hypotheses of Regan (1911) and Berg (1947). Mo (1991) used 114 ossification characters and 12 other morphological features to determine catfish relationships. The resulting construction of Mo (1991) showed that the Diplomystidae is still recognised as the most primitive family, while the Ariidae are considered to be an advanced group. Within the Asian catfish families, Siluridae is considered the most primitive group, which give rise to two major groups. Group I is the Melapteruridae-line which later evolved to give rise to Schilbeidae, Plotosidae, Bagridae, Pangasiidae and Ariidae, while Group II is the Chacidae-line which gave rise to the air-breathing group (Clariidae and Heteropneustidae) and the Akysidae-Amblycipitidae-Sisoridae groups. The Bagridae, Pangasiidae and Ariidae could be considered to be the advanced fish groups. Mo's hypothesis is shown in Fig. 3.1.

Within the Schilbeidae, the fish groups present in Africa and in Asia are different. The African schilbeids (for example *Schilbe*, *Physalia*) possess primitive characters and share some osteological features with the Clariidae and Heteropneustidae. Whilst the Asian schilbeids have structures similar to the Bagridae and Pangasiidae. This suggests that African schilbeids are phylogenetically distant to the Asian schilbeids (see Section 3.5.2).

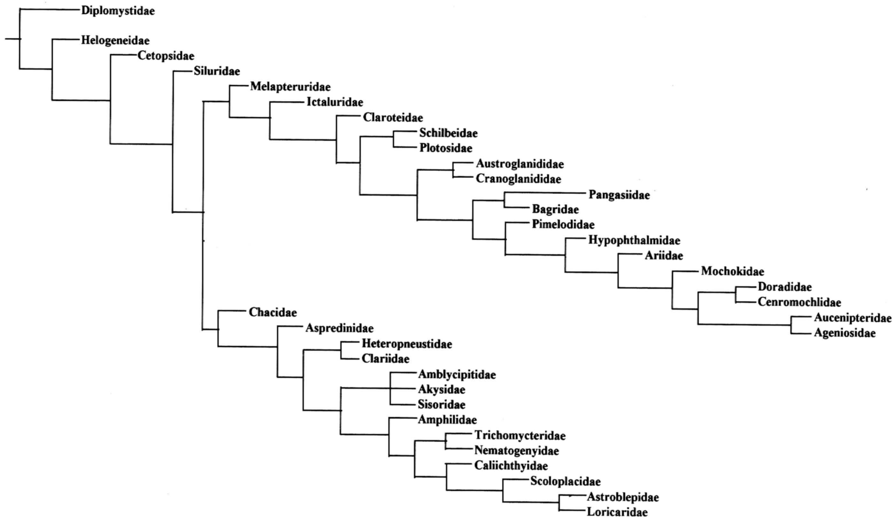

Fig. 3.1 Phylogenetic relationships of the world catfish (Southeast Asian catfish families) (Mo, 1991)

3.4.2 Generic relationships

There are some studies dealing with the phylogenetic relationships of the different genera within the Amblycipitidae (Chen & Lundberg, 1994), Bagridae (see Mo, 1991; Roberts, 1992a, 1989), Pangasiidae (see Roberts & Vidthayanon, 1991; Vidthayanon, 1993; Vidthayanon & Roongthongbaisuree, 1993) and Siluridae (see Bornbusch, 1991, 1995; Bornbusch & Lundberg, 1989; Haig, 1950; Kobayakawa, 1989). However there are no information on the phylogenetic relationships of the different genera in the following families: Akysiidae, Ariidae, Chacidae, Clariidae, Schilbeidae and Sisoridae.

Amblycipitidae

The Amblycipitidae is recognised to be a monophyletic group (Chen & Lundberg, 1994; Mo, 1991), with three amblycipitid genera (see Section 3.3.2.2). *Amblyceps* is considered to be a sister taxon of *Liobagrus*, and not with *Xiuren-bagrus* (see Chen & Lundberg, 1994).

Bagridae (Figs. 3.2 & 3.3)

The phylogenetic relationships of the bagrids are well discussed by Mo (1991). A summarised account will be presented here to assist in the later discussion on the relationships between the hosts and monogeneans (see Section 4.2.2). Traditionally Bagridae (with 200 species and 32 genera) was considered to be a primitive family (see Berg, 1947; Mo, 1991; Regan, 1911). However recent cladistic analysis done on the Bagridae proposed that this family could be advanced group (see Mo, 1991) (Fig. 3.1).

According to Mo (1991), the Bagridae contains 15 genera with 140 species. Based on osteological features, Mo (1991) divided the Bagridae into two sub-families, the Bagrinae (with 13 genera) and the Ritinae (with two genera). Mo (1991) re-assigned all the African bagrids into the family Claroteidae Bleeker, 1862, except for *Bagrus* Bosc, 1816 which was left in the Bagridae (Bagrinae). Only the genus *Bagrus* is restricted to Africa, while the other 14 genera are found in Asia. Eight genera of the Bagrinae are found in Thailand (see Section 3.3.2.4).

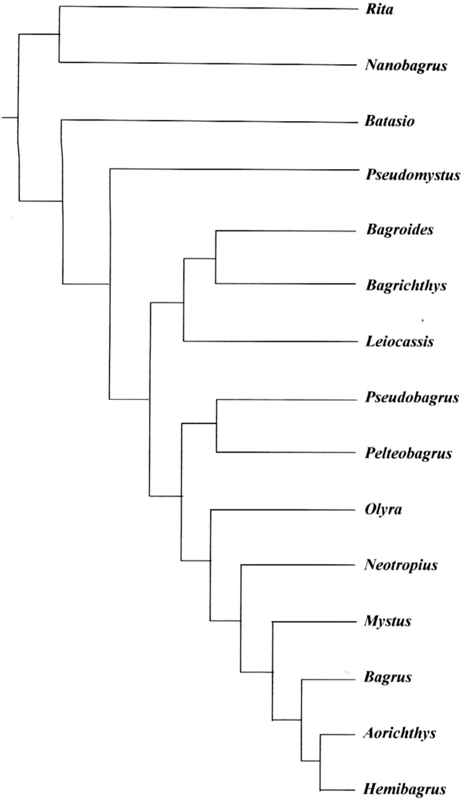

Fig. 3.2 Phylogenetic relationships of the Bagridae (Mo, 1991)

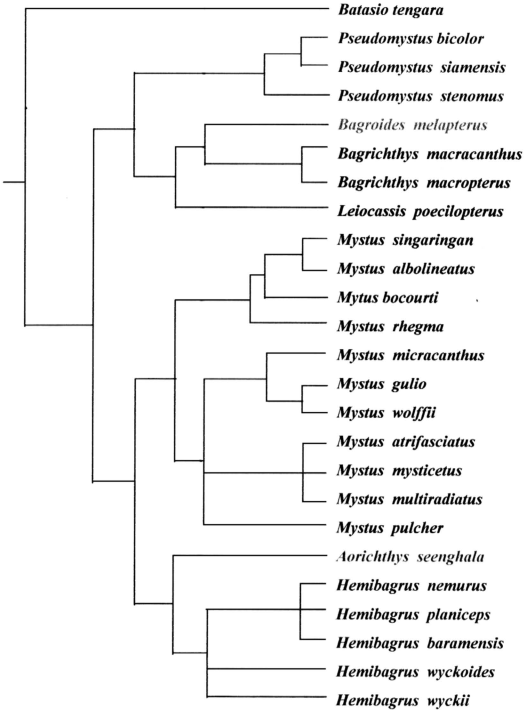

Fig. 3.3. Phylogenetic relationships of Thai bagrids
(based on Mo, 1991; Roberts, 1992a, 1994)

Mo (1991) constructed a cladistic tree with two subfamilies, Bagrinae and Ritinae (Fig. 3.2). Within the Bagrinae there are three main sister groups. Group I consists of *Aorichthys*, *Bagrus*, *Hemibagrus*, *Mystus*, *Neotropius* and *Olyra*; Group II is composed of *Pseudobagrus* and *Pelteobagrus*; Group III contains *Bagroides*, *Bagrichthys* and *Leiocassis*. The other genera in the Bagrinae, *Pseudomystus* and *Batasio* are different from other groups and also from each other and are grouped separately. Mo (1991) concluded that *Batasio* and *Pseudomystus* are phylogentically distant from the other genera in the Bagrinae. The two genera of Ritinae, *Rita* Bleeker, 1858 and *Nanobagrus* Mo, 1991 are considered to be sister groups. Rita contains four species, while *Nanobagrus* is monotypic with a single species, *Nanobagrus armatus* (Vaillant, 1902) (syn. *Leiocassis armatus*). Based on the information from Mo (1991) and Roberts (1992a, 1994) possible phylogenetic tree of Thai bagrids is drawn up (Fig. 3.3).

Pangasiidae (Fig. 3.4)

According to Vidthayanon and Roongthongbaisuree (1993), *Pangasius pleurotaeinia* and *P. micronema* were re-assigned to the genus *Pteropangasius*, and *Pangasius gigas* as well as *P. hypophthalmus* were re-assigned to the genus *Pangasianodon*.

As already stated in Section 3.3.2.8, the classification of Vidthayanon (1993) is based on the osteological features which divided the 21 pangasiid species into two main groups: *Helicophagus* and *Pangasius* groups will be used to generate the relationship tree between the 21 pangasiid species.

Vidthayanon (1993) included into the *Helicophagus* group the two *Helicophagus* species, *H. typus* and *H. waandersii*. The *Pangasius* group contains the other 19 pangasiid species, and these 19 species were further subdivided into five subgroups: *pleurotaenia* (one species), *micronema* (one species), *gigas* (two species), *pangasius* (11 species) and *nieuwenhuisii* (four species) (Fig. 3.4). The *pangasius* and *nieuwenhuisii* subgroups are related based on the presence of an elastic spring formation in the parapophysis of the fourth Weberian vertebra which is not sutured.

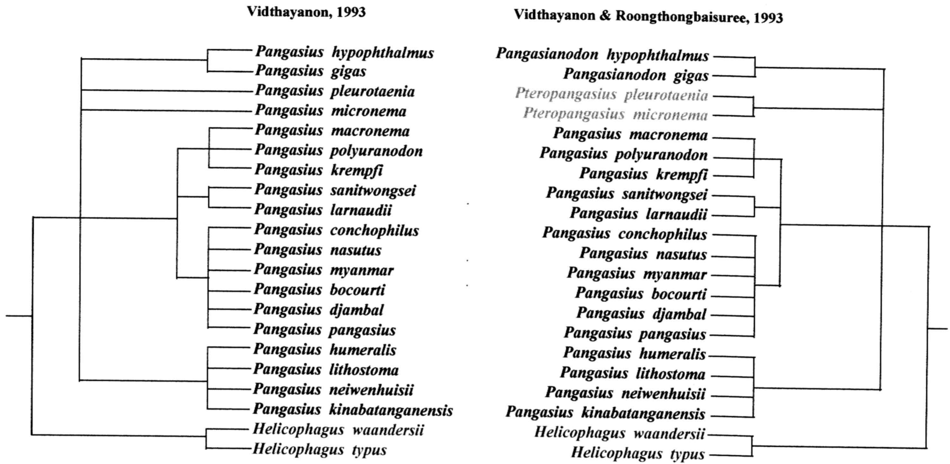

Fig. 3.4 Phylogenetic relationships of the Pangasiidae

(based on Vidthayanon, 1993 and Vidthayanon & Roongthongbaisuree, 1993)

Further division of the *pangasius* subgroups into three groupings are based on the structures of the fin, swim bladder chamber and pelvic girdle: *larnaudii* (two species: *P. larnaudii* and *P. sanitwongsei*), *pangasius* (six species: *P. pangasius, P. myanmar, P. nasutus, P. conchophilus, P. bocourti* and *P. djambal*) and *macronema* (three species: *Pangasius macronema, P. krempfi* and *P. polyuranodon*). The *nieuwenhusii* subgroup includes *Pangasius nieuwenhuisii, P. humeralis, P. lithostoma* and *P. kinabatanganensis*. All the four fish species belonging to the *nieuwenhusii* subgroup are endemic to Borneo (Roberts; 1989; Roberts & Vidthayanon, 1991).

In fact Vidthayanon' s groups and subgroups are equivalent to the four genera suggested by Vidthayanon and Roongthongbaisuree (1993), except that the *Pteropangasius* of Vidthayanon and Roongthongbaisuree (1993) is subdivided into *pleuroteania* and *micronema* in Vidthayanon (1993), while *Pangasianodon* (two species) and *Pangasius* (15 species) in Vidthayanon and Roongthongbaisuree (1993) are divided into five *Pangasius* subgroups, viz., *gigas* (with two species), *pangasius* (with 11 species) and *niewenhuisii* (with four species) in Vidthayanon (1993) (see Fig. 3.4).

Vidthayanon (1993) suggested that the *Helicophagus* group is closely related to the *gigas, pleurotaenia* and *micronema* subgroups, while the *pangasius* subgroup is closely related to the *nieuwenhuisii* subgroup. This indicates that the *Helicophagus* could be more related to the *Pteropangasius* and *Pangasianodon* than to the *Pangasius*.

There are six *Pangasius* species which are present in different regions. *P. pangasius* and *P. myanmar* are present in Indian subcontinent and Myanmar, while *P. conchophilus* and *P. bocourti* are distributed in Indo-China. The other two species, *P. nasutus* and *P. djambal* are restricted to the Sunda region (see Vidthayanon, 1993). This suggests that all the pangasiid species could evolve from Southeast Asia and migrate to Indian subcontinent and Indo-China (see also Vidthayanon, 1993). Based on the information obtained from Vidthayanon & Roongthongbaisuree (1993) and Vidthayanon (1993), a possible phylogenetic tree is drawn up for the Pangasiidae (Fig. 3.4). This scheme is similar to that obtained by ORSTORM group based on molecular data (Pariselle, pers. com.).

Siluridae (Fig. 3.5)

The phylogenetic relationships within the Siluridae was generated using numerical cladistic analysis (Burnbusch, 1995; Kobayakawa, 1989). Based on the osteological features using numerical cladistic analysis, there are four groups within the Siluridae. Group I is composed of the 14 *Silurus* species (except for *Silurus cochinchinensis* group). Group II contains the three species of *Wallago* (*W. attu*, *W. leerii* and *W. maculatus*). Group III contains the two genera, *Silurichthys* and *Silurus (S. cochinchinensis*, *S. bokorensis* and *S. torrentis*). The other six genera, viz., *Hemisilurus*, *Hito*, *Kryptopterus*, *Ompok*, *Ceratogalanis* and *Belodontichthys* are grouped together in Group IV (Fig. 3.5) (see also Bornbusch, 1995).

Within the *Wallago* group, *W. attu* is considered a non-sister group to *W. leerii* and *W. maculatus*. The *Silurichthys* and *Silurus cochinchinensis* groups (*S. cochinchinensis* (syn. *Pterocryptis cochinchinensis*), *S. bokorensis* and *S. torrentis*) are considered to be sister groups. Within Group IV, *Ompok* is considered non-monophyletic with two clads and is separated into four terminal groups: the *O. eugeneiatus* group is more closely related to some species of *Kryptopterus* than to the other *Ompok* species; although *O. bimaculatus*, *O. hypophthalmus* and *O. leiacanthus* are in the same clad, they are considered non-sister groups. *Kryptopterus* is also recognised as a non-monophyletic group, with two clads. Clad I consists of *K. bicirrhis* group, *K. cryptopterus*, *K. schilbeides*, *K. limpok* and *O. eugeneiatus*. All members of this clad are sister groups. Clad II comprises of *K. hexapterus* and *K. apogon* (including *K. bleekeri*), and are recognised as sister groups. The other three silurid genera, *Ceratoglanis*, *Hemisilurus* and *Belodontichthys* which are included in the same clad as the *Kryptopterus* group are also considered as sister groups.

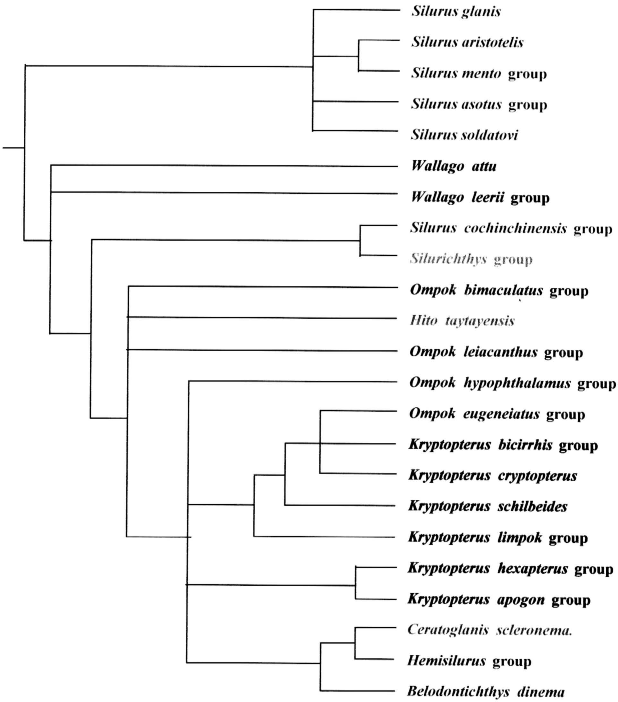

Fig. 3.5 Phylogenetic relationships of the Siluridae

(based on Bornbusch, 1995; Kobayakawa, 1989)

3.5 Distribution patterns of Thai freshwater catfish

The distribution patterns of the 98 freshwater catfish species of Thailand are given in Table 3.1. The freshwater catfish are more diverse in the Central, Northern and Northeastern regions of Thailand, especially in the Chao-praya River and the Me-kong River and their tributaries. For example there are 12 pangasiid species in the Chao-praya River and the Me-kong River basin, while only one species, *Pteropangasius pleurotaenia*, is found in the South (Vidthayanon & Roongthongbaisuree, 1993). The greater diversity in the Chao-praya and Mekong basins is probably due to the larger and longer rivers as well as larger land areas in the Central, North and Northeast regions.

The present survey shows that some catfish species are widely distributed throughout Thailand (Table 3.1); for examples *Clarias batrachus*, *C. macrocephalus*, *Hemibagrus nemurus* and *Ompok bimaculatus*. These four fish species could also be found in other river basins in Southeast Asia (see Kottelat, 1989; Mohsin & Ambak, 1983). However, there are species which are endemic to certain areas because of very specific environmental requirements; for example *Hemipimelodus borneensis* is found in the central region of Thailand but not in the South (Smith, 1945; Vidthayanon, unpublished data), while *Chaca bankanensis* is only reported from swamps with acid sulfate soil in South Thailand.

3.5.1 Affinity of Southeast Asian fish fauna

Southeast Asia which includes Thailand, Peninsular Malaysia, the Island of Borneo, Sumatra, Indonesia and Indo-China are biogeographically known as the Sundaland region which is a subregion of the Oriental realm (Darlington, 1966). The current accepted hypothesis is that the major rivers of the Sundaland regions were connected during the last ice-age. These major rivers probably possessed many species of fish fauna, especially the ostariophysan group (Siluriformes and Cypriniformes) which were dispersed into the adjacent areas. This could explain the similarities in fish fauna in the different regions of Southeast Asia. Many ichthyologists believed that this area was the center of the origin and evolution of catfishes (Briggs, 1979; Darlington, 1966; Roberts, 1989; Smith, 1945) (Section 3.7). As the sea level rose the lower ancient river basins were drowned forming the Sunda platform and the fish fauna become separated (see Roberts, 1989).

Freshwater fish fauna of Indo-China, China, Peninsular Malaysia, Borneo, India and Thailand are closely related (Roberts, 1989). Jayaram (1981) stated that India and Borneo share 40 similar fish species. Kottelat (1989) suggested that the Chao-praya and Me-kong fish fauna have strong affinity with the rest of the Sundaic fauna. The Chao-praya and Me-kong basins have 69 genera (67 %) in common with Borneo, Sumatra and Java, while sharing only 48 genera (47 %) with the Salween basin (Myanmar) and 18 genera (17 %) with Yangtze River system. The fish fauna of Peninsular Malaysia and Thailand are similar with 123 common freshwater fish species (47 %), while Peninsular Malaysia and Borneo have 174 common species (66 %) (see Kottelat, 1989).

There are 13 catfish families are present in the Oriental region, of which 12 families (with 57 genera) are recorded in Southeast Asia: Akysidae (four genera), Amblycipitidae (one genera), Ariidae (five genera), Bagridae (14 genera), Chacidae (one genus), Clariidae (two genera), Heteropneustidae (one genus), Pangasiidae (four genera), Plotosidae (one genus), Schilbeidae (five genera), Siluridae (nine genera) and Sisoridae (ten genera) (see Kottelat, 1989; Roberts, 1989; Shrestha, 1994; Vidthayanon & Roongthongbaisuree, 1993). Cranoglanididae is restricted to China (see Nelson, 1984). Thailand has the greatest diversity of freshwater catfish in Southeast Asian region (with 98 species belonging to 35 genera in 11 families). Whilst 83 freshwater catfish species (27 genera) are recorded from Western Indonesia (Kotellat, *et al.*, 1993), followed by 73 species (25 genera) from Peninsular Malaysia and 24 species (18 genera) from Myanmar (Salawin basin) (Kottelat, 1989). Within the silurid group, 32 species were recorded in the Great Sunda Islands whereas only five species were found in the Indian subcontinent (see Bornbusch, 1995; Jayaram, 1981).

Hemipimelodus is the only true freshwater genus in the Ariidae. Although plotosids could be found in freshwaters in Australia, in Southeast Asia the genus *Plotosus* Lacepede, 1803 (Plotosidae) is marine. Thus far there are no records of plotosids migrating to freshwater systems in Southeast Asia, although *Paraplotosus*

Weber & de Beaufort, 1913 could be found in estuarine-freshwater river of Southeast Asia (see Kottelat *et al.*, 1993).

3.5.2 Affinity with the Ethiopian (African) fish fauna

Although the Ethiopian region (Africa) mainly possess its own catfish groups, for examples, Amphilidae, Mochokidae, Melapteruridae, there are some same catfish groups which are present in both the African and the Oriental regions. The presence of Bagridae, Clariidae, Schilbeidae and Plotosidae in both regions (see Nelson, 1994; Kobayakawa, 1991) indicates that these fish families are widely distributed and suggests that these two regions are related.

However, the members of genera and species of these fish families are different in the two regions: as exemplified by the Clariidae (see Section 3.3.2.6). The number of *Clarias* species in Africa (32 valid species) is higher than that of the Asian *Clarias* (ten species) (see Pethiyagoda, 1991; Teugels, 1986; Smith, 1945).

Morphologically, the African schilbeids are different from the Asian schilbeids. The Indian schilbeids are more similar to Southeast Asian schilbeids than to the African species (Mo, 1991). This suggests that Schilbeidae in Africa could have differentiated allopatrically (Vidthayanon, 1993).

3.5.3 Affinity with the Palearctic fish fauna

Palearctic region includes part of Eurasia (Russia and North China). The Palearctic and Oriental regions share only one freshwater catfish family, Siluridae. *Silurus* is the sole genus of Siluridae recorded in the Palearctic region. Of the 17 *Silurus* species recorded, only four species are found in Southeast Asia. *Silurus cochinchinensis* is a single species present in the Palearctic and Oriental regions (see Kobayakawa, 1989).

3.6 Geological history of Southeast Asia

Many hypotheses have been put forward to explain the distribution of similar species in seemingly unconnected biogeographical areas. To explain the present day distribution patterns of the freshwater fish, it is necessary to understand the geological history of Thailand and Southeast Asia.

Prior to 1980 biologists believed that Southeast Asian region as well as South China were parts of Laurasia (see Whitmore, 1981). However, it is now accepted that the most parts of Asia (India, Turkey, Iran, South and North China, South Tibet, Indo-china and Southeast Asia) as well as Africa, Madagascar, South America, Australia-New Guinea and Antarctica were derived from Gondwana (Audley-Charles, 1987; Metcalfe, 1993; Unrug, 1993). The paleomagnetic data indicates that the core of Southeast Asia composed of four main continental blocks: South China, Indo-China, East Malaya and Sibumasu (parts of Thailand, Burma, West Malaya and Sumatra). These four blocks were completely joined together in the Triassic and with the Eurasian region by late Jurassic. India collided with the mainland of Asia in late Eocene (Metcalfe, 1993).

Other smaller plates, viz., West Burma, Woyla, Semitau and South West Borneo joined this Southeast Asian core forming the Sundaland (or Sunda platform) by late Jurassic to late Cretaceous (see Wu, Van derVoo & Liang, 1989). Sundaland was once a large landmass emerging above the sea during the last ice-age (Hutchison, 1989). There were three main ancient rivers of this area, East Sunda river, West Sunda river and North Sunda river (see Vidthayanon, 1993).

3.7 Centre of the origin of freshwater catfish

There are several hypotheses concerning the centre of origin and dispersion of freshwater fish but only a few of these takes into account plate tectonics (see Kottelat, 1989; Roberts, 1989). Darlington (1966), Smith (1945) and Briggs (1979) believed that the centre of the origin for the catfishes and cyprinids is Southeast Asia (including Indo-China). These fish groups then spread throughout Asia and Africa when the two landmasses were connected in late Cretaceous (Kobayakawa, 1991). Darlington (1966) also suggested that the fish spread to the temperate zone (Europe) and cross the Bering land-bridge to North America and finally to South America. Roberts (1989) too believed that the Sunda drainage (Southeast Asia) could be the evolutionary centre of many fish groups including the Siluriformes such as the Bagridae, Pangasiidae and Siluridae. Roberts (1989) based his hypothesis on the fact that these fish families have endemic genera and species which are restricted to the rivers that formerly were part of the Sunda river.

On the other hand, Novacek and Marshall (1976) suggested that the Ostariophysi first evolved in South America before the breaking up of Gondwana. By the middle of the Cretaceous, the primitive Cypriniformes and Siluriformes separated from Ostariophysi and spread over South America and Africa and then to Asia when the two continents become connected in late of Cretaceous.

Kottelat (1989) suggested that there were three groups of ostariophysan (ancestor of Siluriformes) represented in the three plates of China, India and Southeast Asia and already present and differentiated in the three plates prior to the break-up of Gondwana, thus explaining why Bagridae, Clariidae and Schilbeidae are present in Africa, India and Southeast Asia (see also Lim, 1997).

Although there is presently no evidence to confirm that Southeast Asia is the centre of the origin of catfish, this area contains both primitive and advanced fish species and has the greatest species diversity of the fish group which could support the hypotheses that this area is the origin of the catfish groups (see Briggs, 1979; Kottelat, 1989). It is also possible that all of the catfishes did not evolve from this area alone (see Kotellat, 1989; Mohsin & Ambak, 1983), some groups could have evolved in another region and dispersed into this region later (see later). An example to support this hypothesis is the sisorids, which occur mainly in the Indian subcontinent (Jayaram, 1981).

Two possibilities concerning the place and time of origin of the fish were put forward to explain the similarities between the Southeast Asian and African fish fauna and their monogenean fauna based on the present hypotheses concerning the origin of Southeast Asia (i) the fish could have evolved and dispersed prior to the breaking up of Southeast Asian terranes from Gondwana, probably in the Paleozoic era, or (ii) the fish could have evolved in Gondwana after the break-up of the Southeast Asian terranes, but before India broke away from Africa and the fish fauna could have been carried by India to the present day Southeast Asia when India joined Asian mainland, probably after the late Eocene to the Oligocene era (see Lim, 1997).

Fish fossils

The fossils of fish would assist in determining the time and place of the origin of the catfish. However, there is a paucity in fish fossil records, especially of the siluriforms. Thus far only fossils of clariid were recovered from the lower Miocene in Saudi Arabia (see Lim, 1997).

The discovery of the fossil of lungfish (*Ptychoceratodus* cf. *szechaunensis*) in Thailand and related fishes in South China indicate that South China and Indo-China were connected during the Permian era (see Kottelat, 1989). Wang, Li and Wang (1981) described three fish fossils from the Paleocene of Sanshui, Guangdong Province, China and two of them belong to the *Mystus*. This indicates that the bagrids could be widely present in China (probably also Southeast Asia and Indo-China) during the Paleocene or before. This supports the hypothesis that the Bagridae could have evolved in Southeast Asia or Indo-China which were once parts of the Sunda drainage.

3.8 Summary

The diversity of Siluriformes in Thailand is great (Section 3.5.1). Thailand has 98 freshwater catfish species belonging to 35 genera and 11 families of the Siluriformes. The taxonomic status of the Siluriformes as well as their phylogenetic relationships are frequently being revised. Thailand shares some fish groups with other parts of the Oriental region (Section 3.6.1). The evolutionary status of the siluriforms is also undergoing constant changes and opinions vary according to the authors as to which group is more primitive and which more advanced (Section 3.4.1). Geologically Thailand and Southeast Asia were parts of Gondwana and this is congruent with the distribution pattern of the siluriforms (Section 3.6). Southeast Asia has been hypothesised as the centre of origin for many of the siluriforms (Section 3.7).