

# **A bibliography and categorization of bony fishes exhibiting parental care**

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*Accepted for publication July 1981*

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Parental care occurs in a diversity of fishes, but predominantly among freshwater groups. Among the approximately 422 families of bony fishes (Osteichthyes), 89 are presently known to exhibit parental care. Grouping these families into eight categories, based on the sex of the care-giver(s), reveals male parental care is as common or more common than female parental care. Although unusual among vertebrates, parental care by males alone is very common among bony fishes. Lists of families, the forms of parental care exhibited, the modes of fertilization, the environments in which reproduction occurs, and the sources of documentation are presented. An extensive bibliography and index are provided.

**KEY WORDS:**—Bony fishes - Osteichthyes - parental care - parental roles - reproductive behaviour.

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## INTRODUCTION

Parental care, or non-gametic contributions that enhance the survival and reproductive success of the care-giver's offspring, is a diverse phenomenon among fishes. This care manifests itself in a wide variety of activities involving one or both sexes. The vast amount of information on these phenomena has necessitated and encouraged compilations and reviews. One of the earliest such reviews is that of Gill (1906). Numerous researchers have reviewed specific groups of fishes (e.g. Fryer & Iles, 1972 on cichlids; Wootton, 1976 on sticklebacks); particular

environments (e.g. Gibson, 1969 on littoral fishes; Mead, Bertelsen & Cohen, 1964 on deep sea fishes; Reese, 1964 on marine fishes; Sterba, 1963 on freshwater fishes); or specific forms of parental care (e.g. Amoroso, 1960 on internal gestation; Noakes, 1979 on ectodermal feeding; Oppenheimer, 1970 on oral brooding). Balon (1975a) proposed and detailed a scheme of reproductive guilds for fishes based on aspects of reproductive behaviour and ecology. At present, the most authoritative compilation of parental care in fishes is that of Breder & Rosen (1966). However, Breder & Rosen's comprehensive work is in need of updating. The information presented here partially fulfills that need.

This paper is based on a literature review concentrating on field studies of fish ecology and behaviour. The occurrence of parental care in 89 families of bony fishes (21% of all families) is described by using the systematic classifications of Greenwood, Rosen, Weitzman & Myers (1966) for teleosts, and Breder & Rosen (1966) for non-teleosts. These 89 families are categorized into eight mutually exclusive groups based on the sex of the care-giver(s) in Table 1.

#### PHYLOGENETIC AND ECOLOGICAL FACTORS

The families characterized by parental care represent a wide variety of groups. These families belong to 21 of the 36 orders of bony fishes. Furthermore, complex care-giving behavior can be found among the most primitive families (Latimeriidae, Lepidosirenidae, Amiidae) as well as the most advanced (Blenniidae, Gobiidae, Belontiidae). Notably, the members of the 'superorders' Elopomorpha and Clupeomorpha do not exhibit any parental care. Ecologically, parental care is predominantly a freshwater phenomenon. Among the 89 families characterized by parental care, reproduction in the care-giving species of 50 families occurs exclusively in fresh water. In 32 families, reproduction is in marine, marine intertidal, or estuarine habitats. The remaining seven families have some care-giving species that reproduce in fresh water and other care-giving species that reproduce in marine, marine intertidal, or estuarine habitats. Considering the 15 orders (72 families) in which no parental care is known for any species, the species in 64 families reproduce exclusively in marine or marine intertidal habitats. The species in four families reproduce in fresh water. The remaining four families have some species that reproduce in fresh water and other species that reproduce in marine habitats. The habitat information for the families in these 15 orders was taken from Nelson (1976).

#### DEFINITION OF THE FORMS OF PARENTAL CARE

The forms of parental care known to occur in the bony fishes are listed and defined below. The order in which these forms of care are listed corresponds to how frequently each form occurs (Blumer, 1979).

- Guarding.* Displaying toward and/or actively chasing conspecifics and heterospecifics that approach the eggs or fry, or the site where they are located.
- Nest building and maintenance.* Digging a depression in the substrate, a burrow, or making an elevated mound with substrate materials. Assembling a cup or tube structure with pieces of vegetation. Blowing mucus-covered bubbles that form a floating mass. All these structures are used to hold eggs and/or fry.
- Substrate cleaning.* The removal of detritus, algae, and animals from the site where eggs are to be deposited.

*Fanning.* Moving the pectoral, pelvic, anal, or caudal fins over the egg mass or fry, thereby aerating them and removing sediment. Aeration and removal of sediment may also be accomplished by forcing water over the eggs or fry through the mouth or gill cavities.

*Internal gestation.* Female retains eggs in her body and their development takes place inside the ovaries or oviducts.

*Removal.* Dead or diseased eggs removed by mouth from the egg mass.

*Oral brooding.* Holding eggs and fry in the mouth or gill cavities during their development, typically ending with the release of well developed fry.

*Retrieval.* Taking eggs or fry that fall or stray from the nest or school into the mouth, and returning them to the nest or school.

*Cleaning.* Taking eggs into mouth, manipulating inside the buccal cavity, and returning them to the site from which they were taken.

*External egg carrying.* Eggs attached to the parent externally and carried until hatching.

*Egg burying.* Depositing eggs beneath the substrate surface or covering eggs with substrate material.

*Moving.* Taking eggs or fry by mouth from one location to another, often from one nest to another.

*Coiling.* The parent coils its body around the egg mass while guarding them. This guarding posture reduces the eggs' exposure to air at low tide, when the oviposition site is intertidal.

*Ectodermal feeding.* A specialized mucus produced on the body surface of the parent is used as food by the young fry.

*Brood pouch egg carrying.* Eggs held in a special sac-like external structure during their development.

*Splashing.* Splashing water on eggs deposited out of water or eggs exposed at times of low tide.

Nest building and substrate cleaning are primarily pre-fertilization activities, whereas the other forms of parental care are post-fertilization activities. The term 'egg' refers to either unfertilized ova or the embryonic phase of development or both. 'Fry' refers to either the larval or juvenile developmental phases or both (see Balon, 1975b). Internal fertilization, in and of itself, is not considered to be a form of parental care. For example, species in the families Phallostethidae and Neostethidae have internal fertilization, but embryonic development (cleavage) does not begin until the eggs are released by the female (Roberts, 1971; Villadolid & Manacop, 1934). Neither males nor females attend these embryos. Similar conditions exist for members of the Horaichthyidae (Breder & Rosen, 1966), and for some members of the Cottidae (Hubbs, 1966) and Characidae (Nelson, 1964). Tables 2-9 list the families, forms of care, and references corresponding to each of the eight categories given in Table 1. The modes of fertilization among the caregiving species of each family are also given in these Tables. Table 10 lists the 36 orders of bony fishes and the families that are characterized by parental care. Ecological data and cross references to Tables 2-9 are also given in Table 10.

#### ACKNOWLEDGEMENTS

Financial support was provided by Mr and Mrs N. Blumer and Mr and Mrs R. A. Blumer. I am grateful for the advice, comments, and criticisms of the

following individuals: E. K. Balon, R. M. Bailey, W. D. Hamilton, R. R. Miller, R. A. Nussbaum, G. R. Smith, G. C. Williams, and my fellow graduate students at the University of Michigan. However, any errors or omissions in this work are my own. I also thank K. F. Keyes for her editorial assistance.

TABLE 1

The distribution of families by the sex of the care-giving individual. The 89 families exhibiting parental care are categorized into eight mutually exclusive groups by the sex of the care-giving individual(s). 'Male alone' indicates that when parental care occurs it is given only by the male. 'Male alone and biparental' means that among some species in a family only the male cares for offspring, while among other species in the same family both male and female give parental care (usually together). The meaning of the notation for the other categories follows in a similar manner.

Table 1. The distribution of families by the sex of the care-giving individual

Care given by	Number of families
Male alone	36
Male alone and biparental	5
Male alone and female alone	7
Biparental	10
Male alone, female alone, and biparental	5
Female alone and biparental	3
Female alone	16
Sex not known	7

## KEY TO TABLES 2-9

The symbols below indicate the occurrence of each form of parental care within each family, but do not imply that all species in a family exhibit parental care or all the forms of care listed. See text for definitions of the forms of parental care.

G	Guarding eggs (E) or fry (F)	CE	Cleaning eggs
N	Nest building and/or substrate cleaning	EEC	External egg carrying
F	Fanning and aeration	EB	Egg burying
IG	Internal gestation	M	Moving eggs (E) or fry (F)
RD	Removal of dead or diseased eggs	GEC	Coiling around eggs while guarding
ORB	Oral brooding	EF	Ectodermal feeding of fry
R	Retrieval of eggs (E) or fry (F)	BP	Brood pouch
		S	Splashing eggs deposited out of water

\*, Indicates that the available documentation on the family is poor or questionable.

†, Indicates that the full reference can be found in the bibliography of Breder & Rosen (1966) and is not given in the References here. In cases where a reference was not directly consulted, the source of the secondary citation is indicated by the parenthetical phrase, "as cited by Author, date".

The mode of fertilization for the care-giving species in each family is indicated by (I), Internal fertilization; (E), External fertilization.

Table 2. Families in which the male alone gives parental care

Family	Forms of care	References
Lepidosirenidae (E)	GE, GF, N, F, GEC	Bouillon, 1961; Budgett, 1901a; Carter & Beadle, 1930a†; Johnels & Svensson, 1954†
Amiidae (E)	GE, GF, N	Doan, 1938†; Kelly, 1924†; Reighard, 1900, 1902, 1903
Pantodontidae* (I)	GE	Lastein & van Deurs, 1973; Sachtleben, 1920† (as cited by Breder & Rosen, 1966)
Notopteridae* (E)	GE, N, F	Smith, H. M., 1933†, 1933; Southwell & Prashad, 1919† (as cited by Breder & Rosen, 1966)
Erythrinidae (E)	GE, N	Azevedo & Gomes, 1942† (as cited by Breder & Rosen, 1966); Moreira, 1919† (as cited by Breder & Rosen, 1966)
Lebiasinidae (E)	GE, F, RD, CE, S	Coates, 1933b†; Innes, 1956; Krekorian, 1976; Krekorian & Dunham, 1972; Nelson & Krekorian, 1976; Schapitz, 1962; Shapiro, 1954†
Citharinidae* (E)	GE	Ahl, 1936† (as cited by Breder & Rosen, 1966)
Gymnotidae* (E)	GE	Hopkins, 1974
Cyprinidae (E)	GE, N, F, RD, EB	Greeley, 1929†; Hankinson, 1908, 1932†; Hubbs & Cooper, 1936†; Kryzhanovsky <i>et al.</i> , 1951† (as cited by Breder & Rosen, 1966); McMillan & Smith, 1974; Miller, 1962; Raney, 1939c†, 1940b†; Reighard, 1910; Tsukahara, 1954†; Van Duzer, 1939†; Westman, 1938†; Wynne-Edwards, 1932†
Siluridae* (E)	GE, GF	Aristotle (as translated by Agassiz, 1856); Breder & Rosen, 1966
Clariidae (E)	GE, N	Mookerjee & Mazumdar, 1950†
Plotosidae (E)	GE, N, F	Lake, 1959†, 1967, 1971
Callichthyidae (E)	GE, N	Carbonnier, 1880; Carter & Beadle, 1931†; Dammerhuber, 1935† (as cited by Breder & Rosen, 1966); Hoedeman, 1960; Schubert, 1950†; Vipan, 1886
Loricariidae (E)	F, RD, CE, EEC	Azevedo, 1938† (as cited by Breder & Rosen, 1966); Friswold, 1937a† (as cited by Breder & Rosen, 1966); Isbrücker, 1971; Menezes, 1949
Batrachoididae (E)	GE, N, F, S	Arora, 1948†; Breder, 1941a†; Clapp, 1899; Gray & Winn, 1961†; Greene, 1899; Gudger, 1908; Hubbs, 1920a†; Moore, 1970; Ryder, 1886
Antennariidae (E)	EEC	Pietsch & Grobecker, 1980
Cyprinodontidae (E)	GE, F, RD, EB	Barlow, 1961; Echelle, 1973; Fletcher, 1958†; Herrmann, 1915†; Innes, 1956; Itzkowitz, 1974; Mertz & Barlow, 1966; Nieuwenhuizen, 1961c†; Rachow, 1929† (as cited by Breder & Rosen, 1966); Raney <i>et al.</i> , 1953†
Gasterosteidae (E)	GE, GF, N, F, RD, RE, RF, CE, ME	Assem, 1967; Breder, 1936a†; Iersel, 1953†, 1958†; Köhler, 1926† (as cited by Breder & Rosen, 1966); Leiner, 1930† (as cited by Breder & Rosen, 1966); McInerney, 1969; McKenzie, 1974; McKenzie & Keenleyside, 1970; Morris, D., 1952†, 1958; Reisman, 1963; Reisman & Cade, 1967; Rowland, 1974; Seal, 1932†; Steinke, 1920†, 1921† (as cited by Breder & Rosen, 1966); Winn, 1960†; Wootton, 1971, 1972; Wunder, 1928†, 1930† (as cited by Breder & Rosen, 1966)
Aulorhynchidae (E)	GE, N	Limbaugh, 1962†
Syngnathidae (E)	EEC, BP	Fiedler, 1954; Graham, 1939†; Gudger, 1906; Heincke, 1880 (as cited by Breder & Rosen, 1966); Kujawa, 1960; McCulloch, 1914; Straughan, 1960†; Strawn, 1958†; Takai & Mizokami, 1959†
Synbranchidae (E)	GE, N	Lake, 1971; Taylor, 1913; Wu & Liu, 1942† (as cited by Breder & Rosen, 1966)
Hexagrammidae (E)	GE, F	Clemens & Wilby, 1946†; DeMartini, 1977; Edwards, 1971; Fujita & Uchida, 1959b† (as cited by Breder & Rosen, 1966); Wilby, 1937†

Table 2—*continued*

Family	Forms of care	References
Cottidae (E)	GE, N, F, RD, ME	Bailey, 1952†; DeMartini, 1978a; Downhower & Brown, 1977; Elmhirst, 1915; Ennis, 1970; Hann, 1927†; Ludwig & Norden, 1969; Morris, 1954†; Peek, 1869; Savage, 1963; Simon & Brown, 1943†; Smith, 1923†; Smyly, 1957†; Westin, 1969, 1970
Cyclopteridae (E)	GE, ORB	DeMartini, 1978b; Gilbert, 1895; McIntosh, 1886, 1897; Parr, 1926†
Pseudochromidae (E)	GE, N, F	Lubbock, 1975
Plesiopidae* (E)	GE	Mito, 1955† (as cited by Breder & Rosen, 1966)
Theraponidae* (E)	GE, F	Randow, 1934a† (as cited by Breder & Rosen, 1966)
Centrarchidae (E)	GE, GF, N, F	Avila, 1976; Barney & Anson, 1923†; Beeman, 1924†; Breder, 1936b†; Carr, 1942†, 1946†; Coggeshall, 1923†; Howland, 1932†; Hubbs & Bailey, 1938†; Huck & Gunning, 1967; Hunter, 1963; Keenleyside, 1971, 1972a; Larimore, 1957†; Mathews, 1965; Miller, 1963; Murphy, 1948†; Reighard, 1905; Witt & Marzolf, 1954†
Sparidae (E)	GE, N, F	Hardy, 1959†; Kent, 1883; Penrith, 1972; Wilson, 1958†
Nandidae (E)	GE, N, F, RD, RF	Arnold, 1948a†; Barlow, 1964, 1967; Campbell, 1948b†; Lauppe, 1907 (as cited by Breder & Rosen, 1966)
Labridae (E)	GE, N, F	Fiedler, 1964; Potts, 1974; Söljan, 1930a†, b†, c† (as cited by Breder & Rosen, 1966); Terry, 1951†
Opisthognathidae (E)	GE, N, ORB	Böhlke & Chaplin, 1957†; Colin, 1971; Leong, 1967
Blenniidae (E)	GE, N, F, RD	Brown, 1929†; Fishelson, 1963, 1975; Guitel, 1893a, b; Hildebrand & Cable, 1938†; Hildebrand & Schroeder, 1928†; Holder, 1907; Jones, 1937a†; Lebour, 1927†; Mito, 1954†; Munro, 1955b† (as cited by Breder & Rosen, 1966); Phillips, 1977; Qasim, 1956, 1956b†, 1957†; Raju, 1971; Shiogaki & Dotsu, 1973; Wickler, 1957d†
Tripterygiidae (E)	GE, F	Graham, 1939†; Ruck, 1973a
Kurtidae (E)	EEC	Guitel, 1913; Hardenberg, 1936†; Lake, 1971; Weber, 1910
Tetraodontidae (E)	GE, F	Cohn, 1912 (as cited by Breder & Rosen, 1966); Schreitmüller, 1930a† (as cited by Breder & Rosen, 1966)

Table 3. Families with male alone and biparental care

Family	Forms of care	References
Gobiesocidae (E)	GE, F	Graham, 1939†; Martin & Martin, 1970; Ruck, 1971, 1973b; Runyan, 1962†; Smith, W. A., 1885
Amphipnoidae* (E)	GE, GF, N, RE	Das, 1927†; Finckh, 1917†, 1918† (as cited by Breder & Rosen, 1966)
Pomacentridae (E)	GE, GF, N, F, RD, CE, EF	Abel, 1961†; Albrecht, 1969; Allen, 1972; Breder & Coates, 1933†; Brinley, 1939†; Clarke, 1970; Fishelson, 1964, 1970a; Fishelson <i>et al.</i> , 1974; Fricke, 1974; Keenleyside, 1972b; Limbaugh, 1964; Mapstone & Wood, 1975; Moyer, 1975; Moyer & Bell, 1976; Moyer & Sawyers, 1973; Myrberg <i>et al.</i> , 1967; Robertson, 1973; Russell, 1971; Sale, 1970, 1971; Swerdloff, 1970; Turner & Ebert, 1962; Verwey, 1930†
Anabantidae (E)	GE, N, RE, RF	Berns & Peters, 1969; Forselius, 1957†; Nieuwenhuizen, 1957a†; Rohrbach, 1939c† (as cited by Breder & Rosen, 1966); Peters, 1971

Table 3—*continued*

Family	Forms of care	References
Belontiidae (E)	GE, N, F, ORB, RE, RF, CE (only males ORB)	Bahr, 1955† (as cited by Forselius, 1957†); Braddock & Braddock, 1957†, 1959†; Breder, 1934e†; Carbonnier, 1869; Chang & Liley, 1974; Cheal, 1973; Forselius, 1957†; Friese, 1957a†; Goodrich & Taylor, 1934†; Hall, 1968; Hall & Miller, 1968; Hodges & Behre, 1953†; Innes, 1956; Kramer, 1973; Kühme, 1961; Miller, 1964; Pal & Southwick, 1965; Schmidt, 1957†; Smith, H. M., 1937†

Table 4. Families with male alone and female alone parental care

Family	Forms of care	References
Umbridae (E)	GE, N	Breder & Rosen, 1966; Fowler, 1921†; Hagen <i>et al.</i> , 1972; Landeck, 1914 (as cited by Breder & Rosen, 1966)
Bagridae (E)	GF, N, EEC, EF	Eggert, 1930† (as cited by Breder & Rosen, 1966); Sundararaj, 1962†
Ariidae (E)	ORB	Dmitrenko, 1970; Evermann & Goldsborough, 1902; Gudger, 1916†, 1918†; Gunter, 1947†; Hubbs & Miller, 1960†; Lake, 1971; Lake & Midgley, 1970a; Lee, 1931†, 1937†; Merriman, 1940†; Pantulu, 1963
Apogonidae (E) (I in one species with male parental care)	GE, ORB	Ebina, 1932a†; Fishelson, 1970b; Garnaud, 1950b†, 1962, 1963; Petit, 1931†; Rudel, 1934† (as cited by Breder & Rosen, 1966); Sakamoto, 1930†; Smith, C. L. <i>et al.</i> , 1971
Percidae (E)	GE, F, RD, EB	Adams & Hankinson, 1928†; Atz, 1940†; Constantz, 1979; Lake, 1936†; Raney & Lachner, 1939†; Reeves, 1907; Winn, 1953†, 1958a†, b†
Clinidae (E) (I only in species with IG)	GE, N, F, IG, RE, CE (female care limited to IG)	Al-Uthman, 1960†; Breder, 1939c†, 1941b†; Fusari, 1895 (as cited by Breder & Rosen, 1966); Guitel, 1892a, 1893a; Hubbs, 1952†; Jillett, 1968; Smith, 1950†
Stichaeidae (E)	GE, F, ME, GEC	Clemens & Wilby, 1946†; LeDrew & Green, 1975; Marliave & DeMartini, 1977; Schultz & DeLacy, 1932†; Slipp, 1948a† (as cited by Breder & Rosen, 1966); Wourms & Evans, 1974

Table 5. Families with biparental care

Family	Forms of care	References
Galaxiidae (E)	N	Cadwallader, 1976
Heteropneustidae (E)	GE	Holly, 1928†, 1931† (as cited by Breder & Rosen, 1966)
Aphredoderidae* (E)	GE, N	Eddy & Underhill, 1974
Channidae (E)	GE, GF, N	Alikunhi, 1953; Chacko & Kuriyan, 1947†; Deraniyagala, 1929†; Herre, 1924†; Khan, 1924†; Qayyum & Qasim, 1962; Raj, 1916† (as cited by Breder & Rosen, 1966); Swift, 1935†; Willey, 1909a; Yapchiongco, 1963
Alabetidae* (E)	GE	Haswell, 1890
Serranidae* (E)	GE, N	Dakin & Kesteven, 1938† (as cited by Breder & Rosen, 1966); Lake, 1959†
Nototheniidae (E)	GE, N, F	Daniels, 1978, 1979
Anarhichadidae† (E)	GE, N, GEC	Penfold, 1966
Osphronemidae (E)	GE, GF, N, F, RE	Bhimachar <i>et al.</i> , 1944†; Gill, 1874; Kulkarni, 1943†; Roxas & Umali, 1937†
Balistidae (E)	GE, N, F	Garnaud, 1960

Table 6. Families with male alone, female alone, and biparental care

Family	Forms of care	References
Osteoglossidae (E)	GE, GF, N, ORB (care by female alone limited to ORB)	Budgett, 1901b; Fontenele, 1959† (as cited by Breder & Rosen, 1966); Lake, 1971; Lake & Midgley, 1970b; Luling, 1968; Menezes, 1951† (as cited by Breder & Rosen, 1966); Oliveira, 1944† (as cited by Breder & Rosen, 1966); Scott & Fuller, 1976; Smith, 1931†, 1945†; Svensson, 1933†
Characidae* (E)	GE, GF, N, F, RD, ME	Breder & Rosen, 1966; Braker, 1960, 1963; Budgett, 1901b; Innes, 1956; Ledecy, 1966; Svensson, 1933†
Ictaluridae (E)	GE, GF, N, F, CE	Breder, 1935a†, 1939b†; Clemens & Sneed, 1957†; Eycleshymer, 1901; Fontaine, 1944†; Fowler, 1917†; Smith & Harron, 1904; Taylor, 1969; Wallace, 1972
Cichlidae (E)	GE, GF, N, F, RD, ORB, RF, CE, ME, MF, EF	Aronson, 1948†, 1949†; Atz, 1954†, 1959†; Baerends & Baerends-van Roon, 1950†; Barlow, 1974; Baylis, 1974; Breder, 1934c†; Breder & Rosen, 1966; Bruton & Boltz, 1975; Burchard, 1965; Cichocki, 1977; Coe, 1966; Coeckelberghs, 1975; Dünnebier, 1932† (as cited by Breder & Rosen, 1966); Elder, 1960; El-Zarka, 1956†; Evans, 1952†; Fishelson & Heinrich, 1963; Fryer, 1960a†; Fryer & Iles, 1972; Gordon, 1958†; Graham, 1927†; Greenberg, 1961, 1963; Greenwood, 1956b†; Heinrich, 1967; Hildemann, 1959†; Iles & Holden, 1969; Keenleyside & Prince, 1976; Kuenzer, 1957† (as cited by Breder & Rosen, 1966); Liebman, 1933†; Lowe, 1956a†, 1959†; Lowe-McConnell, 1969; McKaye, 1977a, b; Myrberg, 1965; Noakes & Barlow, 1968, 1973a, b; Noble & Curtis, 1939; Perrone, 1978; Reid & Atz, 1958†; Reinboth, 1956† (as cited by Breder & Rosen, 1966); Ribbink, 1971; Ringelberg, 1935† (as cited by Breder & Rosen, 1966); Ruwet, 1962, 1963; Sawaya & Maranhão, 1946†; Skipper & Skipper, 1956†, 1957† (as cited by Breder & Rosen, 1966); Timms & Keenleyside, 1975; Ward & Barlow, 1967; Ward & Wyman, 1975, 1977; Welcomme, 1967; Werner, 1976; Whitehead, 1962; Wickler, 1962†, 1962, 1965, 1969
Gobiidae (E) (I only in species with IG)	GE, N, F, IG, RD	Anderson <i>et al.</i> , 1971; Auty, 1978; Breder, 1942†, 1943a†; Buen, 1923† (as cited by Breder & Rosen, 1966); Dôtu, 1954†, 1955c†, 1957b†, d†, 1958a†, d†, ef; Ebert & Turner, 1962; Gale, 1914; Gibson, 1970; Guitel, 1892b, 1895; Hamlyn-Harris, 1931†; Harms, 1935† (as cited by Breder & Rosen, 1966); Holt, 1899; Ishikawa & Nakamura, 1940† (as cited by Breder & Rosen, 1966); Jones, 1937a†; Lake, 1959†, 1967; Lassig, 1976; Lozano Rey, 1935† (as cited by Breder & Rosen, 1966); McDowall, 1965; MacGinitie, 1939†; Mashiko, 1976; Mayer, 1929a† (as cited by Breder & Rosen, 1966); Nelson, 1928†; Ninni, 1938† (as cited by Breder & Rosen, 1966); Riedel, 1914 (as cited by Breder & Rosen, 1966); Senta & Wada, 1970; Tavolga, 1950†, 1954†; Weisel, G. F., Jr, 1947†



Table 7. Families with female alone and biparental care

Family	Forms of care	References
Salmonidae (E)	GE, N, EB (males aid in EB only)	Babcock, 1931†; Belding, 1934a†; Briggs, 1953†; Brown, 1938†; Fabricius & Gustafson, 1955†; Frost, 1965; Greeley, 1932†; Needham, 1961; Schultz, 1938†; Schultz & students, 1935†; Shapovalov & Taft, 1954†; Tautz & Groot, 1975
Zoarcidae (E) (I only in species with IG)	GE, IG	Abu Gideiri, 1968; Bretschneider <i>et al.</i> , 1947†; Bridge, 1904; Chute, 1936† (as cited by Breder & Rosen, 1966); White, 1939†
Pholididae (E)	GE, GEC	Ehrenbaum, 1904 (as cited by Gudger, 1927†); Gudger, 1927†; Holt, 1893; Metz, 1912 (as cited by Breder & Rosen, 1966); Qasim, 1956a†; Smith, 1887†

Table 8. Families in which the female alone gives parental care

Family	Forms of care	References
Latimeriidae (I)	IG	Smith, C. L. <i>et al.</i> , 1975
Osmeridae (E)	EB	Templeman, 1948† (as cited by Breder & Rosen, 1966); Thompson, 1919; Thompson & associates, 1936†
Aspredinidae (E)	EEC	Breder & Rosen, 1966; Wyman, 1859
Amblyopsidae (E)	ORB	Eigenmann, 1909
Ophidiidae (I)	IG	Cohen & Nielsen, 1972; Nielsen & Cohen, 1973; Nielsen <i>et al.</i> , 1968; Parr, 1933†; Turner, 1946b†; Wourms & Bayne, 1973; Wourms & Cohen, 1975
Exocoetidae (I)	IG	Breder & Rosen, 1966; Scheidnass, 1956†; Weed, 1933†
Oryziatidae (E)	EEC	Amemiya & Murayama, 1931†; Blanco, 1947b†; Jones, 1937a†; Raj, 1916† (as cited by Breder & Rosen, 1966); Solberg, 1942†
Adrianichthyidae (I)	IG	Weber & Beaufort, 1922†
Goodeidae (I)	IG	Fitzsimons, 1976; Turner, 1940d†
Anablepidae (I)	IG	Eigenmann, 1894; Turner, 1940b†
Jenynsiidae (I)	IG	Breder & Rosen, 1966; Turner, 1940e†
Poeciliidae (I)	IG	Baird, 1968, 1973; Clark & Aronson, 1951†; Constantz, 1975; Depeche, 1976; Gordon, 1955†; Kunz, 1971; Rosen & Bailey, 1963†; Rosen & Gordon, 1953†; Turner, 1940a†
Solenostomidae (I)	BP	Fishelson, 1966; Willey, 1909b
Scorpaenidae (I)	IG	Amoroso, 1960; Fujita, 1957c†, 1958†; Goodchild, 1924† (as cited by Breder & Rosen, 1966); Graham, 1939†; Morris, 1956; Phillips, 1958†, 1964; Rass, 1936†; Takai & Fukunaga, 1971
Comephoridae (I)	IG	Berg, 1965; Dybrowski, 1873, 1901 (as cited by Breder & Rosen, 1966); Tcherniaev, 1971
Embiotocidae (I)	IG	Bane & Robinson, 1970; Carlisle <i>et al.</i> , 1960†; Eigenmann, 1894; Hubbs, 1917†, 1921b†; Ishii, 1957†, 1960†; Lagios, 1965; Rechnitzer & Limbaugh, 1952†; Shaw, 1971; Triplett, 1960; Wiebe, 1968

Table 9. Families in which the sex of the care-givers is not known

Family	Forms of care	References
Polypteridae* (E)	GF	Arnoult, 1966; Kerr, 1907
Gymnarchidae* (E)	GE, N	Budgett, 1901a, b
Hemiodontidae* (E)	GE	Lange, 1934† (as cited by Breder & Rosen, 1966)
Malapteruridae* (E)	ORB	Breder & Rosen, 1966; Gill, 1906
Carangidae* (E)	GE	Shuleikin, 1958†
Gadopsidae* (E)	GE	Jackson, 1978
Luciocephalidae (E)	ORB	Alfred, 1966; Liem, 1967; Tweedie, 1952†

TABLE 10

The orders of bony fishes and a complete list of the families with species that exhibit parental care. The manner in which groups of teleost families are listed follows the cladogram of Patterson & Rosen (1977:120). The number in parentheses after each order is the number of families in that order. The letter symbols that follow each family indicate the habitat in which reproduction occurs for those species that exhibit parental care (F = fresh water, M = marine, MIT = marine intertidal or estuarine). These symbols are also used to characterize the families of orders in which no parental care occurs. The 'Care given by' categories correspond to Tables 2–9 where references for each family are listed.

Table 10. The orders of bony fishes

Non-teleostean fishes	Care given by
Order Coelacanthiformes (1)	
Latimeriidae (M)	Female alone
Order Dipteriformes (2)	
Lepidosirenidae (F)	Male alone
Order Polypteriformes (2)	
Polypteridae (F)	Sex not known
Order Acipenseriformes (2)	
(2F)	No parental care
Order Semionotiformes (1)	
(F)	No parental care
Order Amiiformes (1)	
Amiidae (F)	Male alone
Teleostean fishes	Care given by
Osteoglossomorpha	
Order Osteoglossiformes (4)	
Osteoglossidae (F)	Female alone and biparental
Pantodontidae (F)	Male alone
Notopteridae (F)	Male alone
Order Mormyriiformes (2)	
Gymnarchidae (F)	Sex not known
Elopomorpha	
Order Elopiformes (3)	
(3M)	No parental care
Order Anguilliformes (26)	
(26M)	No parental care
Order Notacanthiformes (3)	
(3M)	No parental care

Table 10—*continued*

Teleostean fishes	Care given by
Clupeomorpha	
Order Clupeiformes (4)	
(1 F, 2M + F, 1 M)	No parental care
Euteleostei	
Order Salmoniformes (37)	
Salmonidae (F)	Female alone and biparental
Osmeridae (MIT)	Female alone
Galaxiidae (F)	Biparental
Umbridae (F)	Male alone and female alone
Order Cetomimiformes (9)	
(9 M)	No parental care
Order Ctenothrissiformes (1)	
(M)	No parental care
Order Gonorynchiformes (4)	
(2 F, 1 F + M + MIT, 1 M)	No parental care
Order Cypriniformes (26)	
Characidae (F)	Male alone, female alone, and biparental
Erythrinidae (F)	Male alone
Lebiasinidae (F)	Male alone
Hemiodontidae (F)	Sex not known
Citharinidae (F)	Male alone
Gymnotidae (F)	Male alone
Cyprinidae (F)	Male alone
Order Siluriformes (31)	
Ictaluridae (F)	Male alone, female alone, and biparental
Bagridae (F)	Male alone and female alone
Siluridae (F)	Male alone
Clariidae (F)	Male alone
Heteropneustidae (F)	Biparental
Malapteruridae (F)	Sex not known
Ariidae (M + F)	Male alone and female alone
Aspredinidae (F)	Female alone
Plotosidae (F)	Male alone
Callichthyidae (F)	Male alone
Loricariidae (F)	Male alone
Order Percopsiformes (3)	
Amblyopsidae (F)	Female alone
Aphredoderidae (F)	Biparental
Order Batrachoidiformes (1)	
Batrachoididae (MIT)	Male alone
Order Gobiesociformes (1)	
Gobiesocidae (MIT)	Male alone and biparental
Order Lophiiformes (15)	
Antennariidae (M)	Male alone
Order Gadiformes (10)	
Ophidiidae (M)	Female alone
Zoarcidae (M)	Female alone and biparental
Order Atheriniformes (16)	
Exocoetidae (F)	Female alone
Oryziatidae (F)	Female alone
Adrianichthyidae (F)	Female alone
Cyprinodontidae (F)	Male alone
Goodeidae (F)	Female alone
Anablepidae (F)	Female alone
Jenynsiidae (F)	Female alone
Poeciliidae (F)	Female alone
Order Beryciformes (12)	
(12 M)	No parental care
Order Zeiformes (6)	
(6 M)	No parental care

Table 10—*continued*

Teleostean fishes	Care given by
Order Lampridiformes (6) (6 M)	No parental care
Order Gasterosteiformes (9)	
Gasterosteidae (F + MIT)	Male alone
Aulorhynchidae (M)	Male alone
Solenostomidae (M)	Female alone
Syngnathidae (M)	Male alone
Order Channiformes (1)	
Channidae (F)	Biparental
Order Synbranchiformes (3)	
Alabetidae (MIT)	Biparental
Synbranchidae (F)	Male alone
Amphipnoidae (F)	Male alone and biparental
Order Scorpaeniformes (21)	
Scorpaenidae (M)	Female alone
Hexagrammidae (M)	Male alone
Cottidae (M + F)	Male alone
Comephoridae (F)	Female alone
Cyclopteridae (M + MIT)	Male alone
Order Dactylopteriformes (1) (M)	No parental care
Order Pegasiformes (1) (M)	No parental care
Order Perciformes (143)	
Serranidae (M)	Biparental
Pseudochromidae (M)	Male alone
Plesiopidae (M)	Male alone
Theraponidae (M)	Male alone
Centrarchidae (F)	Male alone
Apogonidae (M + MIT)	Male alone and female alone
Percidae (F)	Male alone and female alone
Carangidae (M)	Sex not known
Sparidae (M)	Male alone
Nandidae (F)	Male alone
Embiotocidae (M)	Female alone
Cichlidae (F + MIT)	Male alone, female alone, and biparental
Pomacentridae (M)	Male alone and biparental
Gadopsidae (F)	Sex not known
Labridae (M)	Male alone
Opisthognathidae (M)	Male alone
Nototheniidae (M)	Biparental
Blenniidae (F + M + MIT)	Male alone
Anarhichadidae (M)	Biparental
Tripterygiidae (MIT)	Male alone
Clinidae (M + MIT)	Male alone and female alone
Stichaeidae (M + MIT)	Male alone and female alone
Pholididae (MIT)	Female alone and biparental
Gobiidae (F + M + MIT)	Male alone, female alone, and biparental
Kurtidae (F + MIT)	Male alone
Anabantidae (F)	Male alone and biparental
Belontiidae (F)	Male alone and biparental
Osphronemidae (F)	Biparental
Luciocephalidae (F)	Sex not known
Order Pleuronectiformes (7) (5 M, 2 M + F)	No parental care
Order Tetraodontiformes (7)	
Balistidae (M)	Biparental
Tetraodontidae (M)	Male alone

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