

First description of small juveniles of the primitive catfish *Diplomystes* (Siluriformes: Diplomystidae)

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At 13 mm SL young *Diplomystes nahuelbutaensis* are free living and, judging by their greatly diminished yolk mass, probably foraging. External development of form from these small fish to subadults is smooth and continuous, without distinct juvenile stages or specializations. The major changes of body and fin shape shown by *Diplomystes* are those common to most siluriforms and other fishes: juveniles have large heads and eyes, and expanded posterior median-fin membranes relative to larger specimens. Pigmentation pattern is similar in juveniles and adults in this species. Definitive pectoral- and dorsal-fin spines, and fin ray counts, except for caudal-fin procurent rays, are established before firm ossification and segmentation of lepidotrichia. The postcleithral process develops relatively late.

Introduction

In December, 1992 T. M. Berra and V. H. Ruiz collected specimens of the catfish *Diplomystes nahuelbutaensis* in the clear, rocky and fast-flowing Río Laja (Fig. 1) of central Chile, ca. 37° S (Ruiz & Berra, 1994). *Diplomystes nahuelbutaensis* is an endemic and the only diplomystid species known from the Río Bío Bío basin (Arratia, 1987; Ruiz & Berra, 1994). To our knowledge, the specimens in this collection measuring about 13-14 mm SL are the smallest *Diplomystes* known (Figs. 2-3). The smallest diplomystid specimens reported in the literature are twice this size at about 30 mm SL (Arratia, 1983; Azpelicueta & Gosztonyi, 1998).

The largest specimen of *D. nahuelbutaensis* collected with the juveniles is 131 mm SL, thus yielding a growth series from a local population that ranges across one order of magnitude (Fig. 3). Because of the wide interest in *Diplomystes* as a phylogenetically basal, relatively rare and potentially threatened group of siluriforms, we here describe and illustrate these specimens emphasizing the juveniles. Further, we offer general comparisons of the juvenile diplomystids to other siluriforms based largely on a synthesis of scattered published illustrations that summarize the diversity and commonality of juvenile catfishes.

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Fig. 1. Habitat of juvenile *Diplomystes nahuelbutaensis* on Río Laja at La Cantera, 7 km below Salta Laja, Río Bío Bío basin, Chile, December 1992. Photo by T. M. Berra.

Phylogenetic context. Eigenmann & Eigenmann (1890) and Regan (1911) called attention to the primitive nature of *Diplomystes*, emphasizing its dentigerous maxillary bone. The Eigenmanns placed the Diplomystidae at the base of their evolutionary tree diagram of Neotropical catfishes (1890, p. 7). The recognition of *Diplomystes* as primitive among all catfishes has been supported and extended by many subsequent workers: Berg (1940), Chardon (1968), Greenwood et al. (1966), Lundberg & Baskin (1969), Lundberg & Case (1970), Fink & Fink (1981, 1996), Arratia (1987, 1992), Grande (1987), Mo (1991), Azpelicueta (1994a-b), de Pinna (1993, 1998). Diplomystids retain more plesiomorphic characteristics than any other siluriforms. Recent or fossil, including aspects of the maxillary bone, barbels, nares, otic capsule, anterior pterygoid bones, Weberian complex centra, caudal skeleton and fin rays, and pectoral girdle. Nevertheless, monophyly of *Diplomystes* is well supported by synapomorphies of the vomerine and palatine shapes, cranial articulation of the hyomandibula, and heavily papillose skin (Arratia, 1987; Arratia & Huaquin, 1995).

One of the oldest and best preserved fossil siluriforms, †*Hypsidoris*, from the Eocene of North America is the only catfish besides *Diplomystes* that has a toothed maxilla (Lundberg & Case, 1970; Grande, 1987). Otherwise †*Hypsidoris* shares derived characters that diagnose all other recent catfishes (Grande, 1987; Grande & de Pinna, 1998). Grande (1987) proposed a classification to reflect this phylogenetic sequence:

Siluriformes
 Diplomystidae
 Siluroidei
 †Hypsidoridae
 Siluroidea (all other catfishes)

In phylogenetic studies of siluriforms *Diplomystes* and †*Hypsidoris* have been used as a basal 'doublet' outgroup for inferring polarities of character state transformation (Bornbusch, 1991; Friel, 1994). De Pinna (1993, 1998) argued that cetopsid catfishes are also relatively basal among siluriforms, and he questioned resolution of the diplomystid-hypsidorid basal 'doublet' below Siluroidea. In any case, the basal position of *Diplomystes* is well corroborated, and we expect that additional features of these fishes will be identified as plesiomorphic among siluriforms.

Diplomystid distribution and natural history. Six species of Diplomystidae are currently recognized (Arratia, 1987; Azpelicueta, 1994a-b). Berra (2001) depicts the family distribution. Half of the species occur west of the Andes in south central Chile. The trans-Andean species are *D. chilensis* from rivers near Valparaíso and Santiago, *D. nahuelbutaensis* from the Bío Bío basin, and *D. camposensis* from the Valdivia region (Arratia, 1987). Three other species occur east of the Andes in southern Argentina. Arratia (1987) erected the genus *Olivaichthys* for the Argentinian specimens. We follow Azpelicueta (1994a-b) and most subsequent authors who treat *Olivaichthys* as a synonym of *Diplomystes*. The cis-Andean species are *D. viedmensis* from the Río Negro system, *D. cuyanus* from the Río Colorado and the Desaguadero-Salado basin, and *D. mesembrinus* known only from relatively few specimens from Chubut and Senguerr rivers (Azpelicueta, 1994a-b).

Relatively little is known of the habits and life history of diplomystid species. In Chile *Diplomystes* are mostly found to be benthic in fast moving streams, and *D. camposensis* also occurs in lakes (Arratia, 1983, 1987). *Diplomystes viedmensis* has been taken from rivers near sea level to about 1,900 m (Azpelicueta, 1994a). Diplomystids are generalized carnivores that consume annelids, mollusks, and arthropods (Arratia, 1987; Azpelicueta & Gosztonyi, 1998). Specimens of *D. nahuelbutaensis* from fast flowing moderate elevation (370-520 m) tributaries of the Río Bío Bío (Ruiz & Berra, 1994) had eaten aquatic insect larvae, especially chironomids, and the relatively large decapod crustacean *Aegla* (Arratia, 1987;

Ruiz & Berra, 1994). Reproduction occurs at least during the Austral summer based on captures of females with maturing eggs, and the juveniles reported here were collected in December. All diplomystids are considered to be potentially or actually threatened or endangered due to habitat deterioration and predation or competition by introduced trout, *Oncorhynchus mykiss* and *Salmo trutta*. *Diplomystes chilensis* may be extinct (Arratia, 1987).

Material and methods

Material examined: 7 specimens, 12.9-130.6 mm SL, all from Chile: ANSP 177914, 2, 30.7-37.9 mm SL; Río Laja at La Cantera, 7 km below Salta Laja; 9 Dec 1992. – ANSP 177913, 5, 12.9-130.6 mm SL; Río Laja 2 km S of Tucapel, 14 Nov 1992. An additional 27 specimens (not examined in this study but 3 shown in Fig. 2) collected at these same localities are deposited at Ohio State University or Universidad de Concepción, Instituto de Zoología, Chile.

In the descriptions below, specimens of the size series are ordered by standard length (SL) and, where necessary, identified by SL rounded to nearest integer: 13, 14, 31, 38, 55, 71, 131 mm. The 13 and 14-mm specimens are staged as 'juveniles' (Kendall et al., 1984; Fuiman, 1984). Specimens larger than 31 mm SL in our series lack juvenile features and look like small adults, but the series does not include large sexually mature individuals.

Fifty seven measurements (Table 1) were made of the seven specimens in the 13-131 mm size series including straight-line dimensions commonly used in catfish taxonomy and dimensions between 14 homologue landmark points arranged in a truss set (Strauss & Bookstein, 1982). The landmark points and their reference numbers are: 1, anteriormost point of snout; 2, dorsal-fin origin at insertion of first lepidotrichium ('spinelet'); 3L, 3R, left and right pectoral-fin origins at insertions of their spine (first lepidotrichium); 4, dorsal-fin posterior end behind insertion of last lepidotrichium; 5, adipose-fin origin at anteriormost visible inclination of adipose-fin tissue; 6, adipose-fin end at posteriormost attachment of adipose-fin tissue to body; 7, caudal-fin dorsal origin at anteriormost inclination of caudal-fin membrane; 8, base of middle caudal-fin rays over

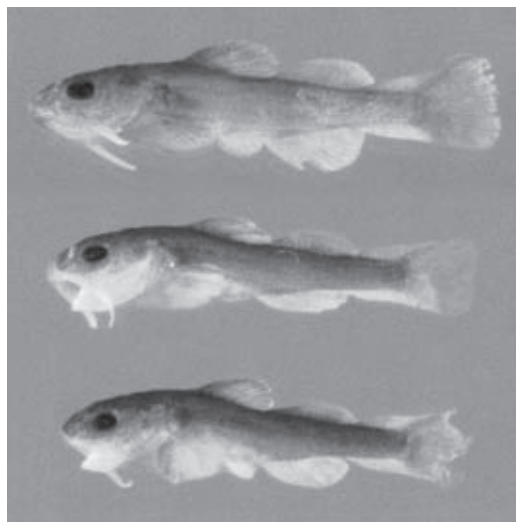


Fig. 2. *Diplomystes nahuelbutaensis*, three freshly captured juveniles from series collected in Río Laja, Río Bio Bio basin, Chile, December 1992. Photo by T. M. Berra.

hypurals; 9, caudal-fin ventral origin at anterior-most declination of caudal-fin membrane; 10, anal-fin posterior end behind insertion of last lepidotrichium; 11, anal-fin origin at insertion of first lepidotrichium; 12L, 12R, left and right pelvic-fin origins at insertions of their first (outer) lepidotrichium.

Bivariate allometric growth relationships are visualized in scatterplots of ratios between measurement pairs vs. SL or head length. Multivariate allometric growth patterns among a subset of 43 non-overlapping measurements were inferred from a Principal Components Analysis of the covariance matrix of log transformed measurement data (Table 2). The scaled factor loadings (coefficients; Sneath & Sokal, 1973) of the 43 dimensions on the first Principal Component (PC 1) were used as multivariate allometry coefficients (Table 2; Bookstein et al., 1985). Allometry coefficients at or near 1.0 indicate an isometric growth relationship between the measured dimension and general body size; values less than or greater than 1.0 indicate negative and positive allometry respectively.

Institutional abbreviations are: ANSP, Academy of Natural Sciences, Philadelphia; CAS, California Academy of Science, San Francisco; DU, Duke University, Durham; USNM, United States National Museum, Washington.

measurement	mean	range
Standard length in mm	50.2	12.9-130.6
Percentage of standard length		
Head length to end of opercular membrane	30.2	27.7-33.0
Head length to end of opercle bone	27.7	24.1-30.6
Snout to adipose fin origin	66.0	63.0-69.5
Snout to pelvic fin origin	48.9	46.2-52.6
Snout to anal fin origin	62.9	59.4-67.1
Head depth at occiput	18.4	14.5-23.9
Adipose fin depth	5.8	4.3- 7.6
Minimum caudal peduncle depth	10.3	9.6-10.9
Body depth at pectoral origin	23.7	22.2-26.6
Pectoral spine length	14.0	11.9-17.7
Dorsal spine length	15.3	11.1-19.2
Longest dorsal fin ray	18.4	13.9-22.1
Longest pelvic fin ray	11.8	8.9-15.1
Longest anal fin ray	16.5	13.5-21.0
Body depth at pelvic origin	17.4	15.6-18.9
Snout to anus	55.2	52.8-57.3
Anus to anal fin origin	6.9	5.1- 8.1
Snout to upper lip	4.4	3.6- 5.5
Postcleithral (humeral) process	5.5	1.0- 8.8
Predorsal length (1-2)	41.6	38.5-45.0
Prepectoral distance (1-3)	28.8	25.1-35.0
Dorsal origin to pect spine (2-3)	22.6	20.1-24.2
Body width across cleithra (3l-3r)	21.7	19.2-25.6
Dorsal fin base (2-4)	13.7	12.4-14.9
Pectoral to pelvic (3l-12l)	23.4	21.1-25.8
Pectoral to dorsal end (3-4)	29.6	25.6-33.3
Dorsal origin to pelvic (2-12)	25.1	23.4-28.8
Dorsal end to pelvic (4-12)	19.4	17.2-22.9
Dorsal end to adipose origin (4-5)	14.0	8.9-18.0
Pelvic to anal origin (12l-11)	14.1	8.3-16.8
Pelvic to adipose origin (12l-5)	24.1	19.4-27.0
Dorsal end to anal origin (4-11)	22.7	17.8-25.3
Adipose origin to anal origin (5-11)	17.8	15.6-19.7
Adipose fin base (5-6)	21.7	17.8-24.4
Anal fin base (11-10)	17.7	14.4-22.2
Anal fin origin to adipose end (11-6)	27.3	25.7-28.4
Adipose origin to anal fin end (5-10)	21.1	18.8-23.9
Adipose end to anal end (6-10)	12.3	10.0-13.5
Length of caudal peduncle upper (6-7)	15.0	12.0-17.8
Length of caudal peduncle lower (10-9)	19.8	16.2-22.8
Anal end to caudal up (10-7)	23.2	21.0-25.4
Adipose end to caudal lower (6-9)	16.9	14.4-19.2
Caudal peduncle depth (7-9)	8.2	7.0- 9.9
Caudal diagonal, dorsal (7-8)	4.0	3.2- 5.2
Caudal diagonal, ventral (8-9)	4.0	3.1- 5.4
Body width at pelvic origin (12l-12r)	9.2	7.6-10.3
Percentage of head length		
Maxillary barbel length	49.4	42.1-60.8
Snout length	42.8	40.9-44.8
Gape width	40.9	32.8-58.3
Width of bony interorbital	35.8	27.4-50.9
Interocular width	43.8	34.9-59.0
Eye diameter, horizontal	19.0	13.8-23.3
Eye diameter, vertical	15.1	12.4-18.1
Eye to posterior nostril	8.4	5.3-11.6
Internarial width	28.7	22.7-36.4
Length of narial apparatus	18.1	16.0-20.8

◁ **Table 1.** Measurement data for the size series of *Diplomystes nahuelbutaensis*; numbers in parentheses after measurement descriptions refer to truss landmark points defined in Methods.

Table 2. Normalized variable loadings on first Principal Component using 43 measurements; numbers in measurement descriptions refer to truss landmark points defined in Methods. Values at or near 1 indicate isometric growth of part or dimension with overall size, values increasingly less than or greater than 1 respectively indicate negative or positive allometric growth.

measurement	multivariate allometry
Interocular distance (width)	0.96
Internarial distance (width)	0.96
Gape width	0.97
Eye diameter horizontal	0.97
Adipose fin depth	0.97
Eye diameter vertical	0.97
Maxillary barbel	0.98
Anal fin base 10-11	0.98
Prepectoral distance 1-3	0.98
Adipose fin base 5-6	0.98
Body width across cleithra 3-3	0.99
Adipose origin to anal fin end 5-10	0.99
Length of caudal peduncle upper 6-7	0.99
Snout length	0.99
Pectoral spine length	0.99
Adipose end to caudal lower lobe 6-9	0.99
Predorsal length 1-2	0.99
Length of caudal peduncle lower lobe 9-10	1.00
Anal fin origin to adipose end 6-11	1.00
Dorsal origin to pectoral spine 2-3	1.00
Anal end to caudal upper lobe 7-10	1.00
Dorsal origin to pelvic 2-12	1.00
Caudal upper lobe to caudal base 7-8	1.00
Length of narial apparatus	1.00
Dorsal fin base 2-4	1.00
Caudal peduncle depth 7-9	1.01
Caudal lower lobe to caudal base 8-9	1.01
Snout to upper lip	1.01
Dorsal end to pelvic 4-12	1.01
Adipose end to anal end 6-10	1.01
Pectoral to pelvic 3-12	1.01
Dorsal spine length	1.01
Pectoral to dorsal end 3-4	1.01
Adipose origin to anal origin 5-11	1.01
Anus to anal fin	1.01
Pelvic to adipose origin 5-12	1.02
Anal fin ray height	1.02
Longest pelvic ray	1.02
Body width at pelvic origin 12-12	1.02
Dorsal end to anal origin 4-11	1.02
Eye to posterior nostril	1.03
Pelvic to anal origin 11-12	1.04
Dorsal end to adipose origin 4-5	1.05

Results

Specimens at 13-14 mm (Figs. 2-3) have lost preflexion larval characteristics, e.g. continuous fin fold and yolk sac. These specimens, however, exhibit several juvenile characteristics (see below for more complete descriptions): all fins discrete although adipose-, caudal- and anal-fin membranes enlarged; fin rays discernable but fibrous, without bony segmentation; incomplete complement of procurrent caudal-fin rays; abdomen slightly distended by residual yolk; head, gape and eyes relatively large (Fig. 3); lateral line canal short and partly open; notochord sharply upturned and at least dermal bone ossification present; postcleithral process scarcely developed. Pigmentation at 13-14 mm generally similar to larger fish.

At 13-14 mm, integument smooth, not covered by papillae or thick mucous. Above 31 mm skin of dorsum and sides with increasingly prominent fleshy, tab-like papillae and mucous. In all specimens skin of isthmus, breast and abdomen thin and smooth. At 13-14 mm branchial membranes thin; in larger fish becoming thick with papillate/plicate texture. Full complement of 8 branchiostegal rays present in all specimens.

All specimens with snout bluntly projecting and upper lip overhanging ventral, transverse mouth. Gape broadest in younger fish (Fig. 4). At 13-14 mm premaxillary, maxillary, and dentary teeth present but tooth counts indeterminate; vomerine dentition indeterminate. By 31 mm dentition of jaws and paired vomerine patches well developed. Lips in 13-14 mm fish thin and non-papillate; in 31 mm and larger specimens lip skin increasingly thick and papillate, particularly around anterior 4 pairs of mandibular sensory pores (Fig. 4).

Eyes fully differentiated at 13-14 mm; orbital rim free but not as deeply infolded as in larger specimens; external nares and thin narial folds fully formed; all head laterosensory canals and pores present; maxillary barbel laterally compressed behind maxilla and nearly reaching pectoral spine insertion (Figs. 2-3). At 13-14 mm lateral line canal incompletely developed, as an open groove terminating below dorsal fin. By 31-38 mm lateral line canal tubular; reaching to below anterior half of adipose; by 55 mm canal complete, terminating over hypurals.

Dorsal fin of all specimens with small spinelet, large non-serrated spine, and 8 anatomically

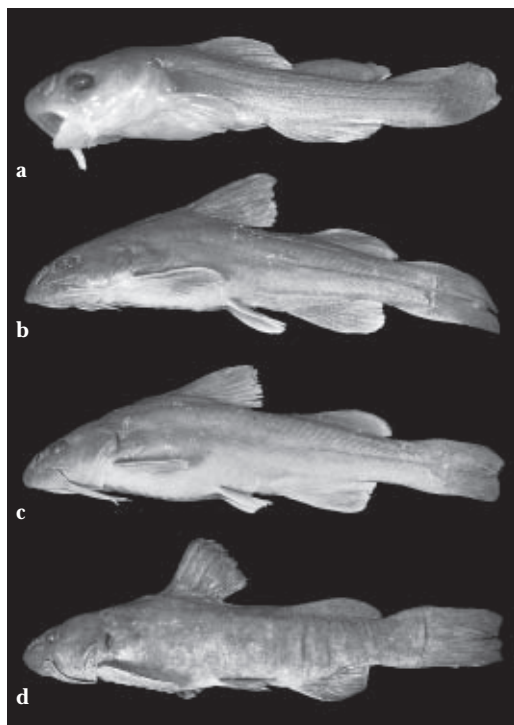


Fig. 3. *Diplomystes nahuelpatensis*, ANSP 177913; a, 13 mm SL; b, 55 mm SL; c, 70.8 mm SL; d, 131 mm SL.

separate soft fin rays (conventionally counted as 7 because last 2 lepidotrichia articulate with terminal pterygiophore). Dorsal-fin spines of 13-14 mm specimens flexible (possibly decalcified after fixation); soft rays fibrous, unsegmented but distally expanded. Dorsal-fin spines of larger fish rigidly ossified; soft rays branched and segmented. Dorsal-fin margin rounded in smallest two fish, becoming truncated in larger specimens. Third to eighth dorsal-fin rays of 13-14 mm specimens reaching to or beyond adipose origin; by 31 mm all dorsal-fin rays falling short of adipose fin.

Adipose fin of 13-14 mm fish relatively long and deep, separate from but overlapping upper caudal-fin membrane (Fig. 2); by 31 mm adipose and caudal fins non-overlapping (Fig. 3). Adipose-fin margin rounded at all sizes; its origin approximately in line with anal-fin origin. Anal fin of 13-14 mm fish relatively long and separate from but last 5 or 6 rays overlapping lower caudal-fin membrane (Fig. 2); anal and caudal fins well separated by 31 mm (Fig. 3). Anal-fin rays 14 or 15 in all specimens.

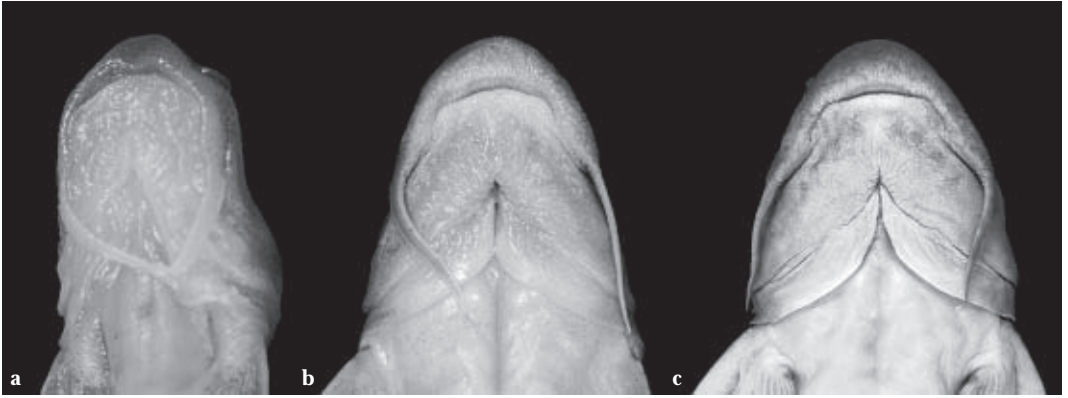


Fig. 4. *Diplomystes nahuelbutaensis*, ANSP 177913, ventral view of head; a, 13 mm SL; b, 70.8 mm SL; c, 131 mm SL.

Caudal-fin margin nearly truncate in smallest specimens becoming distinctly emarginate to shallowly lobed in larger fish. Principal caudal-fin rays 1,8-8,1 in all specimens. At 13-14 mm upper and lower procurrent caudal-fin rays not fully developed, about 10 procurrent rays posteriorly in each lobe; by 55 mm 14-17 procurrent rays in each lobe.

Pectoral fin in all specimens with a large serrated spine and 8 soft rays. At 13-14 mm pectoral spine flexible, with one or two dentations along posterior margin; soft rays fibrous, distally expanded but unsegmented. Spines of larger fish rigidly ossified, with 7-11 strong dentations on posterior margin. Posterior cleithral process scarcely developed in the smallest fish; prominent in specimens 31 mm and larger. All specimens with one or two prominent axillary pores above pectoral fin base. Pelvic fins 6-rayed in all specimens.

Urogenital papilla finger-like at 13-14 mm, becoming increasingly fleshy in larger fish. There is no indication of external sex dimorphism among the specimens at hand.

Upon capture and preserved, 13-14 mm specimens gray on dorsum and head; most densely pigmented around cranial fontanels with black to dark brown chromatophores; countershaded with pale, immaculate skin on abdomen (faint cream to yellowish color internally from remaining yolk) and venter of head. Larger specimens darker overall; dorsum and sides of 55 mm and larger specimens dark gray to nearly black.

Myoseptae of 13-14 mm fish not distinctly marked with pigment as in larger fish. Snout peppered with chromatophores. Proximal half of barbel pigmented, distal half hyaline. Eyes black

except clear pupil and lens occupying central third of eye. Fin membranes mostly clear to hyaline, small chromatophores concentrated mostly along and over fin rays. Dorsal- and pectoral-fin spines diffusely brown to gray. Adipose fin with chromatophores concentrated anteriorly and ventrally; hyaline dorsally and posteriorly. Upper procurrent caudal-fin membrane with scattered chromatophores, the lower procurrent caudal-fin membrane hyaline.

Allometry. Bivariate relative growth patterns of the head, eye, adipose fin and anal fin are presented graphically in terms of changing ratios relative to head or SL in Figure 5. Head length, eye diameter and the basal lengths of the adipose and anal fins exhibit negative bivariate relative growth; while the distances between the dorsal and adipose fins and pelvic and anal fins conversely show positive bivariate allometry.

PC 1 explains 98.5 % of variation of the 43 mensural characters. As expected, this factor is interpretable as a general size measure because all variables load positively and with about the same magnitude. The scaled loadings for PC 1 indicate that none of the measured dimensions of *D. nahuelbutaensis* exhibit strong or unusual patterns of multivariate allometric growth. In fact, most external body regions and parts are isometric with overall size, including fin spines and body depth measures. Negative allometries hold for transverse dimensions of head (interorbital, interocular), eye size, gape width, prepectoral length (a close measure of head length), anal-fin base length, adipose-fin base length and depth, and length of maxillary barbel. Dimensions that

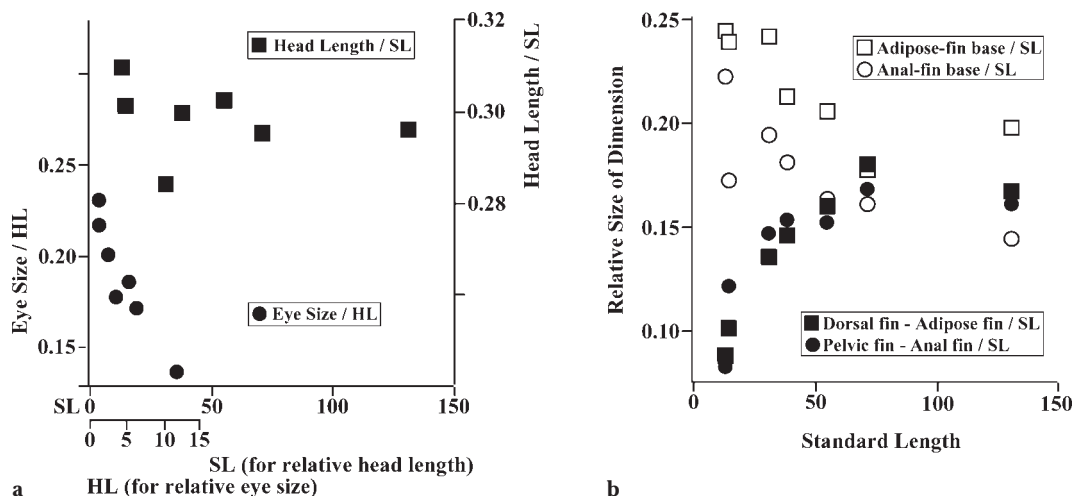


Fig. 5. Scatterplots illustrating allometric growth patterns in *Diplomystes nahuelbutaensis* as changing ratios of body parts relative to HL or SL. **a**, Negative allometry of relative HL vs. SL (■), and relative eye diameter vs. HL (●). **b**, Negative allometry of relative lengths of adipose-fin base (□), and anal-fin base (○) vs. SL and corresponding positive allometry of relative distances between dorsal-fin end to adipose-fin origin (■), and pelvic-fin insertion to anal-fin origin (●) vs. SL.

grow with positive allometry are distances between eye and posterior nostril, dorsal-fin end to adipose-fin origin, and pelvic fin to anal-fin origin. As with the bivariate relationships noted above, these positively allometric measures are the opposites of negative allometries of eye size, and basal lengths of the adipose and anal fins.

Discussion

Siluriformes comprise one of the largest orders of fishes with over 2,800 extant species (>10 % of fish species) placed in about 32 living families. Taxic diversification of catfishes has been accompanied by extensive morphological diversification especially related to trophic, sense organ and locomotory specializations. Siluriforms have an enormous geographical and ecological range in freshwaters and coastal seas around the world, except in Antarctica. In light of their abundance, diversity and the economic importance of many species, there is a surprising and unfortunate paucity of published information on the early life history stages of catfishes. We searched the literature for information and illustrations of late-larval and juvenile catfishes comparable to the youngest *Diplomystes* described here. We found illustrations of juveniles representing species

of Ictaluridae, Bagridae, Cetopsidae, Ariidae, Plotosidae, Heptapteridae, Pseudopimelodidae, Clariidae, Auchenipteridae, Doradidae, Aspredinidae, Trichomycteridae, Callichthyidae, Loricariidae and Pimelodidae. To provide an overview of the diversity of early juvenile external morphology of siluriforms, several published and unpublished illustrations are reproduced here in Figs. 6-8. Most of these are between about 8 and 16 mm SL. We note, however, that standard length is not a criterion for equivalence of developmental stage among catfishes. For example, at about 11 mm, the stout, partly armor-plated loricariid *Rhinlepis* is more advanced developmentally in its musculoskeleton and external form than the ribbon-like pimelodid *Hypophthalmus*. Nevertheless, for broad comparisons these illustrations are useful for showing much diversity of catfish juvenile form. We include a few drawings of larger and more mature specimens of the ariid *Galeichthys feliceps* and the pimelodid *Brachyplatystoma filamentosum* because these still show salient juvenile characters.

Young *Diplomystes* and other juvenile catfishes, like most fishes, have relatively large heads, eyes and posterior median fins in comparison to larger, more mature individuals. Small specimens of *Diplomystes* and most catfish species in the 7-16 mm SL range have remnants of median fin

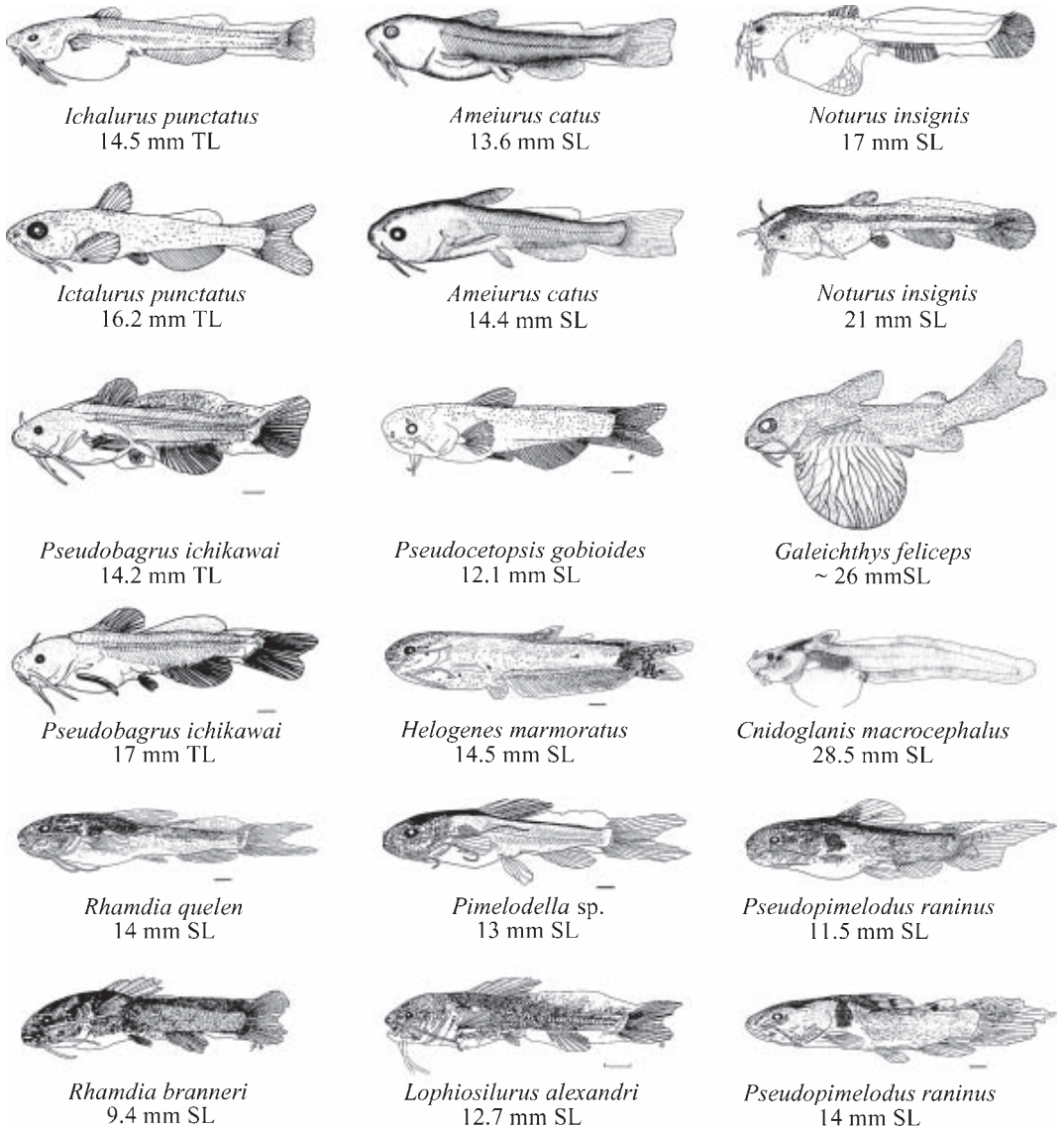


Fig. 6. Juvenile catfishes representing several families as listed below. Unless otherwise indicated, sources in parentheses are: 1=Jones et al. (1978); 2=Nakatani et al. (2001); 3=Ponton & Méricoux. (2001). Starting at top, left: Ictaluridae: *Ictalurus punctatus* (1), *Ameiurus catus* (Mansueti & Hardy, 1967), *Noturus insignis* (1); Bagridae: *Pseudobagrus ichikawai* (Watanabe, 1994); Cetopsidae: *Pseudocetopsis gobioides* (2), *Helogenes marmoratus* (3); Aridae: *Bagre marinus* (1, and after Gudger, 1918); Plotosidae: *Cnidoglanis macrocephalus* (Neira et al., 1998); Heptapteridae: *Rhamdia quelen* (3), *R. branneri* (2), *Pimelodella* sp. (3); Pseudopimelodidae: *Lophiosilurus alexandri* (2), *Pseudopimelodus raninus* (3).

folds and reduced yolk mass. Nevertheless, these juveniles can be readily placed in their families, particularly those with highly derived fin or body shapes, e.g. the plotosid, clariid, trichomycterids and loricariids. In some cases identification to

genus is possible, e.g. the ictalurids *Ictalurus*, *Ameiurus*, and *Noturus* are distinguishable by their caudal fin and body shapes. As far as known for most siluriforms, features that are often characteristic of species such as mouth and fin posi-

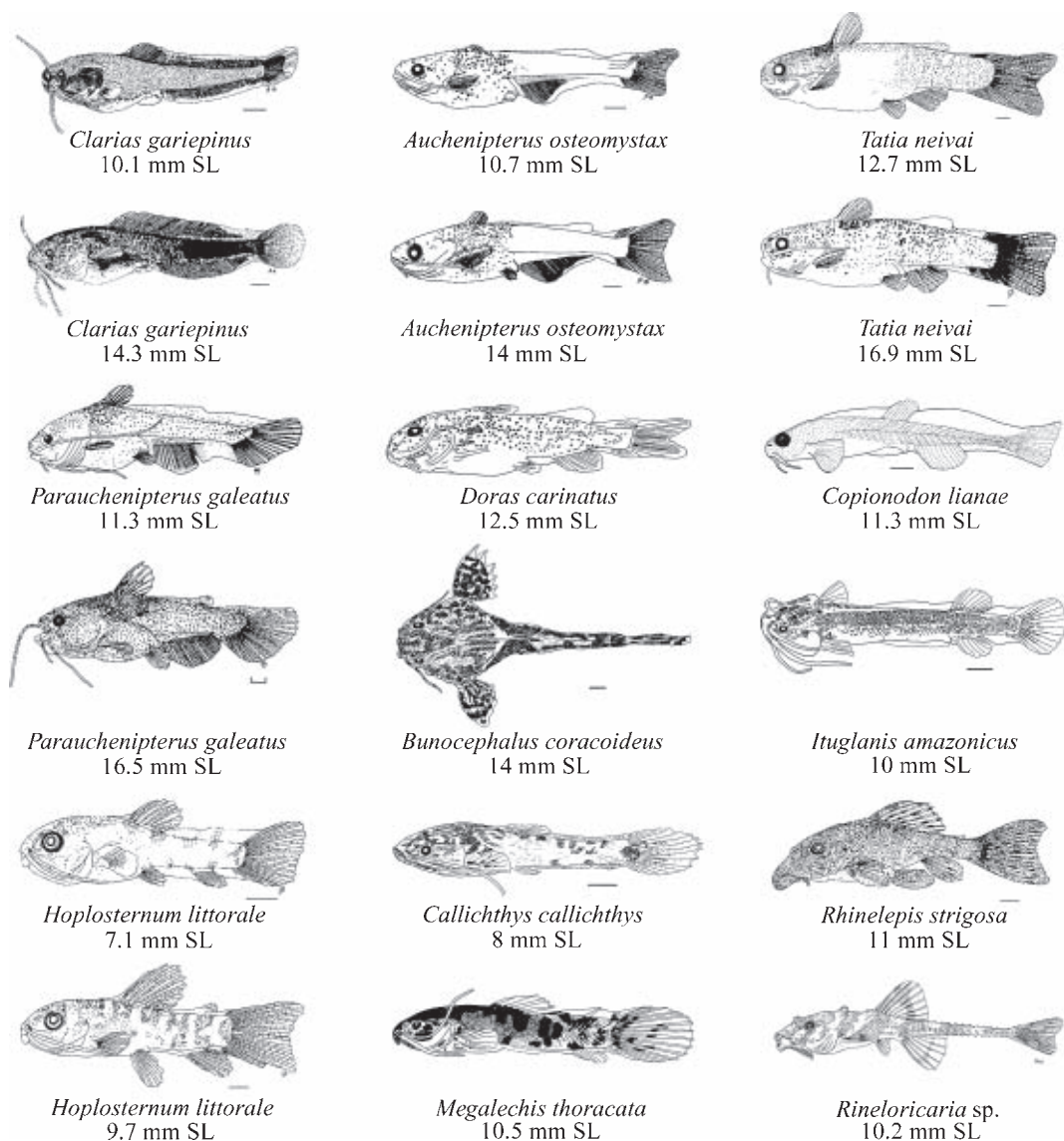


Fig. 7. Juvenile catfishes representing several families as listed below. Unless otherwise indicated, sources in parentheses are: 2=Nakatani et al. (2001); 3=Ponton & Mériçoux. (2001). Starting at top, left: Clariidae: *Clarias gariepinus* (2); Auchenipteridae: *Auchenipterus osteomystax* (2), *Tatia neivai* (2), *Parauchenipterus galeatus* (2); Doradidae: *Doras carinatus* (3); Aspredinidae: *Bunocephalus coracoideus* (3); Trichomycteridae: *Copionodon lianae* (Campanario & de Pinna, 2000), *Ituglanis amazonicus* (3); Callichthyidae: *Hoplosternum littorale* (2), *Callichthys callichthys* (3), *Megalechis thoracata* (3), Loricariidae: *Rhinelepis strigosa* (2), *Rineloricaria* sp. (M. Sabaj, original).

tions, fin shapes, and barbel lengths show little difference between juveniles and adults. For many species, pigmentation pattern is also similar in juveniles and adults. Thus, juvenile catfishes generally resemble and develop smoothly into their adult form without distinct juvenile specializa-

tions. That *Diplomystes* shares this pattern with most catfishes suggests that it is plesiomorphic for siluriforms.

The Ariidae (Jones et al., 1978) and some Pimelodidae (Mago-Leccia et al., 1986; Lundberg et al., 1989) are exceptions to the foregoing conserv-



Brachyplatystoma rousseauxii
13.9 mm SL



Steindachneridion sp.
12.3 mm SL



Zungaro zungaro
8.6 mm SL



Brachyplatystoma filamentosum
21 mm SL



Steindachneridion sp.
13.6 mm SL



Zungaro zungaro
11.4 mm SL



Pseudoplatystoma corruscans
10.4 mm SL



Sorubim cf. *lima*
13.7 mm SL



Sorubimichthys planiceps
10.1 mm SL



Pseudoplatystoma corruscans
14.9 mm SL



Sorubim cf. *lima*
15.4 mm SL



Sorubimichthys planiceps
11.1 mm SL



Hypophthalmus edentatus
11.8 mm SL



Pinirampus pirinampu
10.4 mm SL



Iheringichthys labrosus
10.3 mm SL



Hypophthalmus edentatus
16.8 mm SL



Pinirampus pirinampu
25.6 mm SL



Iheringichthys labrosus
15.7 mm SL



Pimelodus maculatus
12.9 mm SL



Pimelodus ortmanni
7.6 mm SL



Pimelodus pictus
16.2 mm SL



Pimelodus maculatus
14.6 mm SL



Pimelodus ortmanni
9.7 mm SL

Fig. 8. Juvenile pimelodid catfishes. Sources in parentheses are: 1=Mago Leccia et al. (1986); 2=Nakatani et al. (2001). Starting at top, left: *Brachyplatystoma rousseauxii* (1), *B. filamentosum* (1), *Steindachneridion* sp. (2), *Zungaro zungaro* (2), *Pseudoplatystoma corruscans* (2), *Sorubim* cf. *lima* (1); *S. cf. lima* (2), *Sorubimichthys planiceps* (1), *Hypophthalmus edentatus* (2), *Pinirampus pirinampu* (1), *Iheringichthys labrosus* (2), *Pimelodus maculatus* (2), *P. ortmanni* (2), *P. pictus* (1).

ative pattern of development. Ariid young are provided with a large volume of yolk that remains in a prominent yolk sac well into advanced juvenile stages while being mouth-brooded by the males. Among pimelodids, the large sized, riverine *Brachyplatystoma* have specialized pelagic young with greatly elongated barbels and fin filaments, and strongly ornamented pectoral spines. Other large pimelodids, such as *Pseudoplatystoma*, *Sorubim* and *Sorubimichthys* whose young inhabit vegetated, marginal waters, have distinctive cryptic coloration patterns and much enlarged caudal and pectoral fins. These features are clearly derived phylogenetically and are apparently related to specialized life histories.

Comparative material. *Diplomystes nahuelbutaensis*: CAS 55423 (ex. IU 15522), holotype; Chile: Río Cautín (surface and x-ray digital images examined via internet in the California of Academy type specimen image-base: <http://www.calacademy.org/research/ichthyology/Types> [the x-ray reveals a complete specimen of *Aegla* in type's stomach]). – ANSP 84194; Chile: Angol, El Vergel. *D. chilensis*: USNM 84345; Chile: Santiago Market. *D. camposensis*: ANSP 177915; Chile: Lago Piuhue. *D. cuyanus*: DU F913; Argentina: Río San Juan.

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