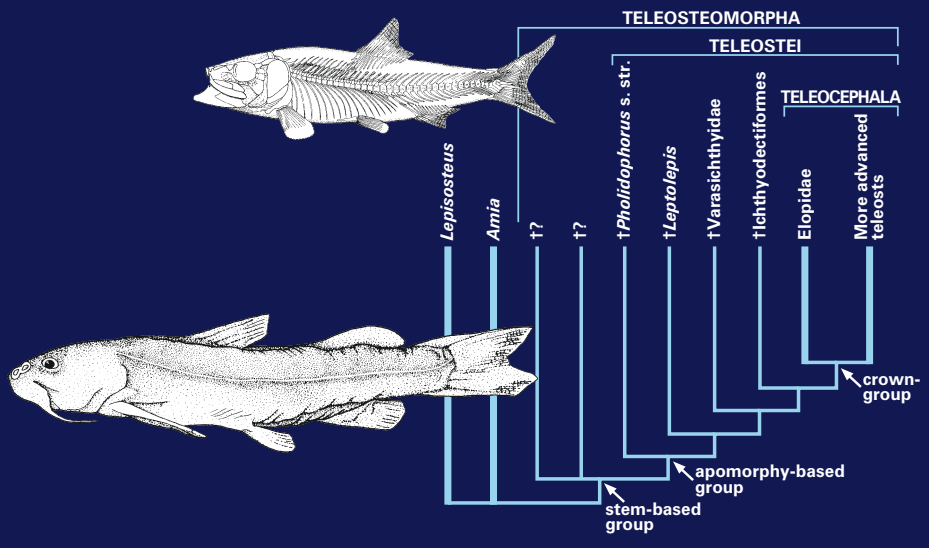
Origin and Phylogenetic Interrelationships of Teleosts

Honoring Gloria Arratia

Joseph S. Nelson, Hans-Peter Schultze &
Mark V. H. Wilson (editors)



Verlag Dr. Friedrich Pfeil · München

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J. S. Nelson, H.-P. Schultze & M. V. H. Wilson (eds.): pp. 11-36, 8 figs., 2 tabs.
 – ISBN 978-3-89937-107-9

Gloria Arratia's contribution to our understanding of lower teleostean phylogeny and classification

Joseph S. Nelson

Abstract

Few ichthyologists have contributed as greatly to the field of lower teleost systematics as Dr. Gloria Arratia. Born in 1942 in Santiago, Chile, Gloria became interested in evolution and its processes while a high school student. This interest was further developed at university where she studied vertebrate morphology in much greater detail than was common at the time. After she graduated from the University of Chile she began to work on extant Chilean catfishes, gaining much expertise on fish osteology. She subsequently started working also on fossil fishes, beginning in the Atacama Desert. In her highly successful career she has conducted research in Chile, Argentina, Germany, Sweden, and the U.S.A. Ever since the mid-1980s, Gloria has been a leading figure in resolving many questions that has given us a better understanding of the origins and limits of the teleosts and of early teleost phylogeny. This has largely been through detailed studies of the morphology of fossil and recent fishes, allowing her to solve problems of homology and to better understand the evolution of characters and evolutionary changes within various groups. She has described many taxa, both living and fossil. She has made major contributions in understanding siluriform morphology and evolution, in understanding basal teleosts morphology and evolution, and in providing valuable insight into the problem of which is the more primitive extant teleost taxon, the osteoglossomorphs or the elopomorphs. She is involved in numerous research projects, e. g., she is currently one of the principal investigators in the Tree of Life of Cypriniformes, supported by NSF, and conducting morphological and developmental studies. Amongst her many editorial functions and administrative duties, she has served as Editor-in-Chief of the Mesozoic Fishes volumes and spearheaded the four Mesozoic Fishes conferences. In recognition of her outstanding contributions, she has received numerous awards, including the Alexander von Humboldt Prize, 1994, the Robert H. Gibbs, Jr. Memorial Award, 2007, and the Artedi Lecturer Diploma, 2008.

Introduction

Understanding the morphology and homologies of early teleosts, the beginnings of teleostean evolution, and developing hypotheses of relationships of early teleostean taxa, continues to be a major challenge in fish systematics. Many leading paleoichthyologists and neoichthyologists have done extensive and highly regarded research on understanding lower teleostean phylogeny, often leading to divergent conclusions. Most of the career of Dr. Gloria Arratia has been spent researching and resolving high-level questions posed in ichthyology and making new discoveries, and she has achieved the highest level of accomplishments and recognition. She has had a remarkable career conducting research on the morphology, ontogeny, and phylogenetic relationships of fossil and recent lower teleosts, as well as on many other actinopterygians (e. g., cheirolepidiforms and polypteriforms), and has added greatly to our understanding of lower teleostean phylogeny and classification. She has taken the field in new directions and posed new questions based on her observations. She continues to make outstanding discoveries.

Gloria Arratia was born 16 October 1942 in Santiago, Chile, being given a name meaning 'glory' in Spanish. She was born as María Gloria Eliana Arratia (her father's surname) Fuentes (her mother's

Fig. 1.
Gloria's mother (a teacher of biology and chemistry who after marriage dedicated 100 % to the family) and her father (a lawyer and the highest judge of the Labor Court of Chile) in 1986.

surname). Her professional name is Gloria Arratia. Her birth was two years before the death of the most active systematic paleoichthyologist of the previous many decades, Arthur Smith Woodward of the British Museum (Natural History), London. It was one year after William A. Gosline received his PhD from Stanford University for his research on the systematics of South American catfishes, an extant fish taxon that captivates Gloria's interests.

Gloria was born into a large extended family with one sister and 23 first cousins from the maternal side alone. All were very close and shared many wonderful times. Her parents (Fig. 1), as typical for professionals in Chile, were moderately well to do. Gloria attended junior and senior high school from 1952-1960 at the Liceo de Niñas Nº 8, Santiago. In 1952, she received first prize in a literary competition among children in Santiago, with an essay entitled "Friendship". In 1954, she received first prize for being the best student in competing with students from other junior schools in Santiago. In 1960, she received the Pedro Alarcón prize. The check that she was presented for this prize at her graduation ceremony for having the highest scholastic achievement in high school allowed her to move to the next stage in her education by covering almost all her expenses at university for the next five years (Fig. 2).

Gloria led an active social life in high school as well at university. She was leader of the students of the high school from 1958 to 1960, representing them in front of teacher and parent organizations, as well as in front of the student's federation in Santiago. Gloria was a well grounded student and actively participated with her classmates in activities such as dancing, watching movies, and participating in sports such as basketball. Proving that beauty and brilliance can go together, she was a Beauty Queen during high school, and then again in 1961 and in 1963 when at the University of Chile (the latter occasion was a big surprise to her with her classmates submitting her nominating materials). In 1961, Gloria passed the examinations named "Bachillerato" from the University of Chile (one of the oldest and most

prestigious universities in South America), and she proceeded directly into the next stage for her studies in biological sciences. In 1966 she received a Professor in Biology and Natural Sciences, from the University of Chile, a degree no longer given by this university, having completed a thesis on the reproductive physiology of mammals under the direction of Professor Héctor Croxatto (main advisor), a medical doctor and highly regarded Chilean physiologist. Although knowing that she would not continue in the subject, she learned valuable scientific skills that would later serve her well as an ichthyologist. This was important because in Chile, at that time, there was no specialist in evolutionary morphology, and she had to educate herself. Along with the common curriculum, she took extra courses in order to learn more about genetics, histology, embryology, philosophy of sciences, and sociology. In addition, as a student, she was an "Ad-honorem assistant" in comparative morphology of vertebrates from 1963 to 1965. She took this official instructor position at the University of Chile for training of highly qualified students. No payment was involved, just the honor to learn more. In all, she achieved maximum honors.

Fig. 2.
Gloria at her high school graduation in 1960 and about to be surprised with a check for being the best student.

How Gloria became involved in fish research. As a high school student Gloria developed an early interest in evolution, having read about Darwin's ideas and his expedition to South America. At university her interest soared as she learned more, and as she discovered that she had a particular interest in conducting evolutionary research of her own. She took extra courses and chose to do her thesis with Professor Croxatto, a leader of an internationally renown group of physiologists who were highly demanding, well organized, and very disciplined in applying scientific methodologies. When Gloria finished her studies in 1966 she obtained a permanent position as second assistant in Comparative Morphology of Vertebrates. One day on campus she met Professor N. Bahamondes (Hydrobiology) who told her that he was looking for her. He knew of her interest in morphology, evolution, and vertebrates and asked Gloria what her plans were for the future. He advised that she should work on some group of vertebrates, suggesting that it be on fishes. He then proceeded to tell her about the wonderful fishes living along the coast of Chile and the many interesting freshwater fishes in South America, but he added that she would have to learn on her own. They met the next day and talked more about the systematics of the fishes, and, much to his delight, Gloria later agreed to take the challenge. Professor Bahamondes was the one who in 2001 presented Gloria to the Academy of Sciences of Chile when she became a member. Gloria began to work with Chilean fishes, especially catfishes, and in a short time she became deeply involved in research on living South American freshwater fishes (Fig. 3). She went on to make outstanding contributions to vertebrate anatomy, bring up to date old descriptions and distributions of extant and fossil taxa, describe new species, and advance our knowledge of the phylogenetic and biogeographical relationships of many taxa. She worked on the taxonomic status and biogeography of South American siluriforms, perciforms, cyprinodontids, and other fishes. In addition, she had and still has a strong interest in training young people.

Fig. 3.
Gloria's early days working on living fishes in Limari river (they caught the first *Trichomycterus* catfish known from this particular semi-arid region of northern Chile when she was having a few days of vacation in 1980) – the other person in the picture is her stepson Jürgen.

How Gloria became involved in fossil fishes. Gloria had been working with freshwater fishes for some years when a tall man carrying a heavy container appeared one day in her office. He introduced himself as Rodolfo Casamiquela. Gloria had been recommended to this famous Argentinian vertebrate paleontologist and anthropologist, who was working in Chile at that time, by his colleagues as a Chilean who knew about fishes and osteology. He was just returning from northern Chile, the Atacama Desert, and had encountered Guillermo Chong, chief of the Geological Survey of Antofagasta, who had found Jurassic fishes in excellent preservation. He had convinced Chong that the material should be studied because it could be an important find. He left Gloria in charge of the material, expecting that she would do her best with it! When Gloria opened the parcel she was marveled by the beauty of the material, having never before held a fossil. She decided then that she would study these fossils. In putting together literature on fossil fishes, she discovered that the libraries had very few papers on the subject. She began to set up a personal library on paleontology and began to learn about fossils. She soon became more familiar with the fossils, started to publish on them, and she subsequently decided to apply for a fellowship and visit other institutions in other countries and talk to ichthyologists. In 1972, during this early period learning about fossil fishes, Gloria met Osvaldo Reig, a famous Argentinian evolutionary biologist and paleontologist, when he was invited by the University of Chile to give a course on systematics. Gloria became fascinated by his views of phylogenetic systematics and took special care in reading the Spanish translation of Hennig (1968) supervised by O. Reig. He, Reig, later provided a strong letter of support for Gloria when she applied for a research fellowship of the A. von Humboldt Foundation, Bonn.

Fig. 4.
Gloria working on fossil fishes in northern Atacama Desert in 1976. She is showing the place were she just recovered a new fish – the fish turned out to be a stem-group teleost.

Gloria's post-student life. As noted above, Gloria had a strong interest in living and fossil fishes starting in her university years. She first had a position in a morphology group, but soon, in 1968, she obtained a higher position in general biology and genetics that permitted her to further develop her research interests. Through administrative changes she was moved to the veterinary (Campus Oeste) and then forestry faculty (Campus Sur) but staying with her group and always teaching the basic courses in biology to the students of these faculties and also of medicine. It was during the 1970s that she started doing extensive field work in Chile (including in rivers in Chile and Argentinian Patagonia and different fossil localities in northern Chile; Figs. 4, 5) that was greatly valued by the forestry faculty. In pursuit of her curiosity and desire to broaden her knowledge, she continued her education by taking special professional training in such areas as fish cytogenetics with Professor H. Campos at the Austral University in Valdivia (1972), Chilean geology with Professor J. Corvalán at the University of Chile (1974-1976), and ecology with Professor E. Hajek at the Catholic University in Santiago.

Gloria successfully applied in 1976 for a Humboldt research fellowship to work with Jurassic fossil fishes from the Atacama Desert. She spent 14 months (1977-1978) in Göttingen, Germany, with Professor Hans-Peter Schultze (where she first met him), to learn vertebrate paleontology. Gloria brought with her superb fossil fish material showing three-dimensionally in Ca-phosphate preserved muscles, these being the only fossil fishes that she was familiar with. While thoroughly familiar with fish morphology, she did not at the time realize just how rare such detail was in fossil fishes and was quite surprised that an authority such as Hans-Peter should be puzzled about what was being seen. She returned to Santiago, where she was head of the biology group (four faculty members and several teaching assistants) of the

Fig. 5.
Gloria trying to escape from the heat to look for some fossil specimens that she had found in the southern Atacama Desert in 1979.

forestry faculty. She married Hans-Peter Schultze in 1980, her second marriage, and moved to Lawrence, Kansas, U.S.A., in 1981.

Following this move, Gloria along with Hans-Peter Schultze, turned Kansas University into a dynamic and important center for systematic ichthyology. She was and is involved in training US and international graduate and postdoctoral students (e. g., X. Y. Chen from China/U.S.A.; F. Poyato-Ariza, A. de la Peña Zarzuela, and R. Soler-Gijón from Spain; D. Thies from Germany; J. Casciotta from Argentina) in systematic ichthyology and morphology in an atmosphere of constant discussion, debate, and nurturing. This training program involving graduate and postdoctoral students (e. g., A. López-Arbarello and J. Casciotta from Argentina; Zhang Jiang-yong and Zhu Min from China; V. Parmar from India) continued in Berlin, with the addition of a special training program in morphology for ichthyologists (e. g., A. Boron and J. Szlachciak from Poland).

Gloria has two PhD dissertations or equivalent, an achievement that resulted from an unusual demand placed on her when seeking an academic position in Germany (in accompanying Hans-Peter to Berlin when he was appointed in 1994, as noted below, to a distinguished directorship). The first such degree was obtained in Chile in 1966 and the second 30 years later in 1996 in Historical Geology and Paleontology at the University of Uppsala, Sweden. This second degree was obtained because in Germany the recognition of foreign degrees is a complicated process, done by previous recognition of a degree from a specific university – never had a biology degree from the University of Chile been recognized. In order to validate her studies in Germany she was required to present official papers, signed by the Ministry of Education and countersigned by the Ministry of Foreign Affairs of Chile, of her achievements from the first year in the elementary school to the last year at the university, including the content of educational programs, grades, and dates of final examinations for each class. Unfortunately for Gloria, as a result of

Fig. 6.
Gloria enjoying reading to her 4 and a half year old granddaughter Kelli, January 2002.

her high qualifications and self discipline as a student, as her records showed, she had completed her studies as a student in a shorter time than most students. This deviation from what was thought normal was not welcomed by administrators in Germany. Thus, Gloria decided that during the couple of years that it would take her to get all documents from Chile, she would write another thesis just to demonstrate that she was able to achieve high-quality results in a short time. The Uppsala dissertation was deemed the best ever presented in the history of the Department. Her advisors were John Peel, the director of the Department of Historical Geology and Palaeontology, and Hans Bjerring (Museum of Natural History, Stockholm). The opponent was Mark V. H. Wilson. This dissertation was the basis for her 1997 book "Basal teleosts and teleostean phylogeny" (Arratia 1997a).

No doubt as with some others, Gloria found it difficult to pursue a scientific career and be a mother at the same time. Her parents helped take care of her children so that she could have her university position, but she chose at an early age to balance work and family, strongly believing that neither should be sacrificed. Conducting research and being a mother was especially difficult when she first moved to the U.S.A. because of the lack of resources at the time for working mothers. In addition to her sharing life with Hans-Peter, Gloria feels blessed with having as part of her life two very generous, intelligent, and beautiful daughters and one granddaughter, Kelli (Fig. 6).

Summary of academic career. From 1966 to 1981 she held various teaching, administrative, and research positions at the University of Chile, Santiago. During this time she held a prestigious research fellowship with the A. von Humboldt Foundation, Germany, in the Geological-Palaeontological Institute in Göttingen in 1977-1978 (and then again in the U.S.A., in 1984-1985). In 1981, in moving to Lawrence, Kansas, she was Adjunct Curator, Division of Ichthyology and Division of Vertebrate Paleontology, Museum of Natural History, the University of Kansas, until 1996 (and Adjunct Professor, Department of Systematics and Ecology, 1987-1996). During this time she gave many courses and lectures elsewhere (Fig. 7). In 1994, she accompanied her husband Hans-Peter Schultze, who upon his retirement from the University

Fig. 7.
Gloria with Chilean ichthyologists when she was giving an intensive course on fish morphology organized by the Austral University of Chile, Valdivia. January 1989. Second row from left to right: late Hugo Campos, Universidad Austral, Margarita Marchant, Universidad de Concepción, Hilda Montecinos, Universidad Austral, student, Ciro Oyarzún, Universidad Católica de Concepción, Julio Lamilla, Universidad Austral, Germán Pequeño, Universidad Austral, late Ismael Kong, Unversidad de Antofagasta; front row left to right: Alfonso Rubilar, Universidad de Concepción, Victor Hugo Ruiz, Universidad de Concepción, Gloria Arratia, Kansas University, Jorge Jaramillo, Universidad Austral, Robert Stead, Universidad Austral, Federico Winkler, Universidad Católica del Norte, Coquimbo, and Laura Huaquín, Universidad de Chile.

of Kansas, accepted the position of Director of the Institut für Paläontologie, Museum für Naturkunde of the Humbolt-Universität, Berlin (Cloutier 2004). From 1996 to 2005, Gloria was Curator of Fishes, Museum für Naturkunde, Institut für Paläontologie, Berlin. In 2004 Hans-Peter moved back to Lawrence, Kansas, and Gloria joined him in 2005, where she continues to serve as Courtesy Research Professor, Department of Ecology and Evolutionary Biology and as Associate Researcher, Division of Ichthyology, Biodiversity Research Center and Natural History Museum. She is also an Associate Researcher of the Field Museum of Natural History, Chicago.

Research projects and funding. Gloria's research has been funded by a succession of grants and awards from many national and international agencies. For instance, the University of Chile Research Grants; National Research Commission of Chile (FONDECYT); Alexander von Humboldt Foundation, Bonn; Muséum National d'Histoire Naturelle, Paris; the Swedish Institut and European Research Council; German Academic Exchange Program (DAAD); German National Science Foundation (DFG); R. O. Bass Visiting Scientific Fund, Field Museum of Natural History; National Geographic Society; and U.S.A. National Science Foundation (NSF). Beginning in August 2004, Gloria has been involved as one of the principal investigators in the Tree of Life of Cypriniformes supported by NSF. In conducting morphological and developmental studies, she is responsible for finding characters of systematic importance of a large number of extant and selected fossil species representing various families and subfamilies. The final goal of the program, as its name implies, is to produce a phylogenetic hypothesis of Cypriniformes based on morphological, ontogenetic, paleontological, and molecular evidence.

Fig. 8.
Gloria and others at the First Mesozoic fish conference in Eichstätt, Bavaria, 1993.

Honors and awards. She has received many awards and honors – The Humboldt Prize (for contribution to Sciences), A. v. Humboldt Foundation, Bonn (1994); Honorary Member, Chilean Society of Ichthyologists (2000); Honorary Member, American Society of Ichthyologists and Herpetologists (2001); Member of the Academy of Sciences of Chile (2001); The Robert H. Gibbs, Jr. Memorial Award, 2007, for "An outstanding body of published work in systematic ichthyology", American Society of Ichthyologists and Herpetologists; un "Homenaje a la Trayectoria" (an homage for her lifelong contribution to Chilean fish paleontology) in 2008 at the I Simposio de Paleontología en Chile, in remembrance of the 200th birth anniversary of Rodulfo Amando Phillipi (1808-1904) and in connection with activities of The International Year of the Planet Earth; and most recently she was honored with an Artedi Lecturer Diploma, in memory of Petrus Artedi, the father of modern ichthyology, for outstanding and world-leading contributions in the field of the nature, interrelationship and distribution of fishes, at the Royal Swedish Academy of Sciences (KVA), which is jointly supported by the KVA, the Swedish Museum of Natural History, and FishBase Sweden, 2008. In 2009, she was named Honorary Professor of the Universidad de Chile, Facultad de Ciencias.

Publication record. To date, Gloria has described some 59 fossil taxa and 14 extant taxa (Table 1). She has had two genera and two species named in her honor (Table 2). She has published over 3200 pages of research (see Bibliography below). In addition to research papers, Gloria has published a few manuals for students of the University of Chile (not included in the Bibliography or in the count of pages given above). Amongst these is a 400 page manual on comparative morphology of vertebrates co-authored with V. Alegría in 1967.

Beginning in 1965, Gloria has contributed to over 100 papers at scientific meetings, many being invited or keynote papers given by herself. She has not only made tremendous advances through her own research, but has also organized numerous symposia and editing papers for publication, most notably four International Meetings of Mesozoic Fishes (Fig. 8) [in Germany (2), Switzerland, and Spain and is helping in the organization of the next one, in Mexico].

Teleostean origins, phylogeny, and classification

The origins and limits of the teleosts have preoccupied the interests of Gloria Arratia for well over 20 years. Teleosts with about 27,000 extant valid species, about 96 % of all extant fishes, are the most species-rich and diversified group of all the vertebrates (Nelson 2006), and a taxon whose origins go back to the Triassic, about 216 to 203 million years ago. Arratia (1996a, 2004) has shown that teleosts, after radiating in the Triassic, possibly from one of the so-called †'pholidophoriform' subgroups, diversified

Table 1.
Taxa described by Gloria Arratia. For references see Bibliography.

†*Pholidophorus domeykanus* Arratia, Chang & Chong, 1975	n. sp.	†'Pholidophoriformes'
†*Leptolepis opercularis* Arratia, Chang & Chong, 1975	n. sp.	†'Leptolepidiformes'
†*Protoclupea* Arratia, Chang & Chong, 1975	n. gen.	†Crossognathiformes
†*Protoclupea chilensis* Arratia, Chang & Chong, 1975	n. sp.	†Crossognathiformes
†*Percichthys lonquimayensis* Chang, Arratia & Alfaro, 1978	n. sp.	Perciformes
Bullockia Arratia, Chang, Menu-Marque & Rojas, 1978	n. gen.	Siluriformes
Trichomycterus mendozensis Arratia, Chang, Menu-Marque & Rojas, 1978	n. sp.	Siluriformes
†Varasichthyidae Arratia, 1981	n. fam.	†Crossognathiformes
†*Varasichthys* Arratia, 1981	n. gen.	†Crossognathiformes
†*Varasichthys ariasi* Arratia, 1981	n. sp.	†Crossognathiformes
†*Chongichthyidae* Arratia, 1982	n. fam.	†Crossognathiformes
†*Chongichthys* Arratia, 1982	n. gen.	†Crossognathiformes
†*Chongichthys dentatus* Arratia, 1982	n. sp.	†Crossognathiformes
†*Santosius* Arratia, 1982	n. gen.	Perciformes
†*Percichthys sandovali* Arratia, 1982	n. sp.	Perciformes
Orestias laucaensis Arratia, 1982	n. sp.	Cyprinodontiformes
Orestias parinacotensis Arratia, 1982	n. sp.	Cyprinodontiformes
Trichomycterus chungaraensis Arratia, 1983	n. sp.	Siluriformes
Trichomycterus laucaensis Arratia, 1983	n. sp.	Siluriformes
Trichomycterus duellmani Arratia & Menu-Marque, 1984	n. sp.	Siluriformes
Trichomycterus roigi Arratia & Menu-Marque, 1984	n. sp.	Siluriformes
†*Domeykos* Arratia & Schultze, 1985	n. gen.	†Crossognathiformes
†*Domeykos profetaensis* Arratia & Schultze, 1985	n. sp.	†Crossognathiformes
†*Protoclupea atacamensis* Arratia & Schultze, 1985	n. sp.	†Crossognathiformes
†*Bobbichthys* Arratia, 1886	n. gen.	†Crossognathiformes
†*Atacamichthys* Arratia & Schultze, 1987	n. gen.	Halecostomi incertae sedis
†*Atacamichthys greeni* Arratia & Schultze, 1987	n. sp.	Halecostomi incertae sedis
Diplomystes camposensis Arratia, 1987	n. sp.	Siluriformes
Diplomystes nahuelbutaensis Arratia, 1987	n. sp.	Siluriformes
Olivaichthys Arratia, 1987	n. gen.	Siluriformes
†*Daitingichthys* Arratia, 1987	n. gen.	Elopomorpha
†*Daitingichthys tischlingeri* Arratia, 1987	n. sp.	Elopomorpha
†*Eichstaettia* Arratia, 1987	n. gen.	Elopomorpha
†*Orthogonikleithrus* Arratia, 1987	n. gen.	Salmoniformes
†*Orthogonikleithrus leichi* Arratia, 1987	n. sp.	Salmoniformes
†*Palaeocichla* Casciotta & Arratia, 1993	n gen	Perciformes
Ostarioclupeomorpha Arratia, 1996	higher category	
The 1996 doctoral dissertation was published in 1997 (see text)		
†*Cavenderichthys* Arratia, 1997	n. gen.	Teleostei incertae sedis
†Orthogonikleithridae Arratia, 1997	n. fam.	'Salmoniformes'
†*Orthogonikleithrus hoelli* Arratia, 1997	n. sp.	'Salmoniformes'
†*Leptolepides haertesi* Arratia, 1997	n. sp.	'Salmoniformes'
†*Tischlingerichthys* Arratia, 1997	n. gen.	Ostariophysi incertae sedis
†*Tischlingerichthys viohli* Arratia, 1997	n. sp.	Ostariophysi incertae sedis
Silvinichthys Arratia, 1998	n. gen.	Siluriformes
†Ferrifronsidae Arratia & Chorn, 1998	n. fam.	Acanthomorpha
†*Acanthichthys* Arratia & Chorn, 1998	n. gen.	Acanthomorpha
†*Acanthichthys major* Arratia & Chorn, 1998	n. gen.	Acanthomorpha
†*Lepidotes tendaguruensis* Arratia & Schultze, 1999	n. sp.	†Semionotiformes
†*Anaethalion zapporum* Arratia, 2000	n. sp.	Elopiformes
†*Ascalabothrissops* Arratia, 2000	n. gen.	†Ichthyodectiformes
†*Ascalabothrissops voelkli* Arratia, 2000	n. sp.	†Ichthyodectiformes
†*Elopsomolos* Arratia, 2000	n. gen.	Elopiformes
†*Elopsomolos frickhingeri* Arratia, 2000	n. sp.	Elopiformes

Table 1.
(Continued).

†*Siemensichthys* Arratia, 2000	n. gen.	Teleostei incertae sedis
†*Siemensichthys siemensi* Arratia, 2000	n. sp.	Teleostei incertae sedis
Teleosteomorpha Arratia, 2001	higher category	
†*Paraleptolepis* Arratia & Thies, 2001	n. gen.	†Leptolepidiformes
†*Paraleptolepis wiedenrothi* Arratia & Thies, 2001	n. sp.	†Leptolepidiformes
†*Engaibatis* Arratia, Kriwet & Heinrich, 2002	n. gen.	Rajiformes
†*Engaibatis schultzei* Arratia, Kriwet & Heinrich, 2002	n. sp.	Rajiformes
†*Longilepis* Arratia 2003	n. gen.	†'Leptolepidiformes'
†*Saldenoichthys* López-Arbarello, Arratia & Tunik, 2003	n. gen.	Perciformes
†*Saldenoichthys remotus* López-Arbarello, Arratia & Tunik, 2003	n. sp.	Perciformes
†*Ameghinichthys* Arratia, Scasso & Kiessling, 2004	n. gen.	Actinopterygii incertae sedis
†*Ameghinichthys antarcticus* Arratia, Scasso & Kiessling, 2004	n. sp.	Actinopterygii incertae sedis
†*Antarctithrissops* Arratia, Scasso & Kiessling, 2004	n. gen.	†Ichthyodectiformes
†*Antarctithrissops australis* Arratia, Scasso & Kiessling, 2004	n. sp.	†Ichthyodectiformes
†*Cheirolepis schultzei* Arratia & Cloutier 2004	n. sp.	Cheirolepidiformes
†*Indiaichthys* Arratia, López-Arbarello, Prasad, Parmar & Kriwet, 2004	n. gen.	Perciformes
†*Indiaichthys bamanborensis* Arratia, Lopez-Arbarello, Prasad, Parmar & Kriwet, 2004	n. sp.	Perciformes
†*Prosantichthys* Arratia & Herzog, 2007	n. gen.	†Parasemionotiformes
†*Prosantichthys buergeni* Arratia & Herzog, 2007	n. sp.	†Parasemionotiformes
†Sorbinichthyidae Alvarado-Ortega, Ovalles-Damián & Arratia, 2008	n. fam.	†Ellimmichthyiformes

and radiated in the Jurassic to occupy all continents by the Late Jurassic (Arratia 2004), about 150 to 145 million years ago. As inferred above, the †'pholidophoriforms' are not monophyletic and Arratia has dedicated the last 10 years revising this group along with the non-monophyletic †'leptolepiforms' (e.g., Arratia 1991, 2000, 2008a). She is in the process of completing separate monographs on Triassic and on Jurassic †'pholidophoriforms'.

As noted by Arratia (2001), Johannes Müller (Müller 1845: p. 198) erected the subclass Teleostei to contain "all true fishes with intermuscular bones, without muscles on the basal position of the arteria [ventral aorta], and two arterial valves [in the conus arteriosus]" (translation by Hans-Peter Schultze). Because most of the diagnostic characters considered by Müller are soft anatomical features, there has been much uncertainty on what fossil fishes to include in the Teleostei as defined by Müller. Some workers accepted the taxon while others felt it to be polyphyletic, e.g., Berg (1940) did not recognize the Teleostei as a valid taxon.

The first modern classification of teleosts was that by (Greenwood et al. 1966). Although published before cladistics was adopted in ichthyological publications, the arrangement was that of a vertical classification and as a consequence resembled a cladistic interpretation (unlike the horizontal classification followed by Gosline 1971). In their diagram of evolutionary relationships (p. 349), they recognized three main lineages derived from pholidophorid holosteans and four higher level taxa that we continue to recognize as follows (Divisions named by Greenwood et al. 1967):

Division I – Taeniopaedia (Elopomorpha + ?Clupeomorpha)
Division II – Archaeophylaces (Osteoglossomorpha)
Division III – Euteleostei (all others, e.g., Protacanthopterygii, Ostariophysi)

Table 2.
Taxa named in honor of Gloria Arratia.

†*Lepidotes gloriae* Thies, 1989	n. sp.	†Semionotiformes
†*Arratiaichthys* Richter & Breitkreuz, 1997	n. gen.	†Palaeonisciformes
†*Arratiaelops* Taverne, 1999	n. gen.	†Ichthyodectiformes
†*Plesiomyxocyprinus arratiae* Liu & Chang, 2009	n. sp.	Cypriniformes

Many workers subsequently revised our views on the phylogenetic relationships of the teleosts. Notable among these is Gloria Arratia who made major contributions in this area, but a sample of these is left primarily to the next section. Some of the key papers of others are mentioned here. A few presented views based on what I regard as independent evidence (e.g., Gosline 1971, Springer & Johnson 2004), and others gave critical summaries and variously reinterpreted the findings of others and/or presented conclusions based on new characters (e.g., Lauder & Liem 1983, Stiassny et al. 2004, Nelson 1994, 2006).

Gloria has made many important contributions in clarifying the homology of the neural arch characters, which are important in reconstructing teleost phylogeny. The first to mention that the presence of modified ural neural arches, known as uroneurals, is a teleostean synapomorphy, was R. Lund (1967). Then, in an important 1968 paper with a deceptively simple title, C. Patterson demonstrated that teleosts, as defined on the basis of the uroneurals and other characters of the caudal skeleton, are a monophyletic group (Patterson 1968). Later, Patterson (1973) included the †pachycormiforms and the †pholidophoriforms in the Teleostei, mainly based on the assumption that these fishes have uroneurals. However, Arratia & Lambers (1996) demonstrated that the uroneurals in †pachycormiforms have a different origin and structure than the uroneurals in †*Leptolepis coryphaenoides* and more advanced teleosts. Patterson (1977) reviewed various attempts to classify teleosts as well as changes in the philosophy of classification and in definitions and composition of the group.

In contrast to the arrangement of Greenwood et al. (1966), we now generally recognize recent teleosts with four main lineages following studies of G. J. Nelson (1969, 1973) and Patterson & Rosen (1977). G. J. Nelson (1969: p. 534) considered the Osteoglossomorpha the most basal of the four taxa, and he, unlike in subsequent work, had the Clupeomorpha listed before Elopomorpha. He classified the neopterygians as follows:

Infraclass Neopterygii
- Division Holostei
- Division Teleostei
  - Cohort Osteoglossomorpha
  - Cohort Clupeomorpha
  - Cohort Elopomorpha
  - Cohort Euteleostei
    - Superorder Protacanthopterygii
    - Superorder Ostariophysi
    - Superorder Neoteleostei

G. J. Nelson (1973), while supporting the above concept of four cohorts of the Teleostei, suggested that there is a relationship between the Clupeomorpha and Euteleostei based on the fusion pattern of lower jaw bones giving three groups: Osteoglossomorpha, Elopomorpha, and a group with all other teleosts. However, he felt it premature to combine the Clupeomorpha and Euteleostei in a formal systematic category.

Patterson & Rosen (1977) defined the Teleostei cladistically, recognizing the Osteoglossomorpha as sister to the Elopomorpha + Clupeomorpha + Euteleostei (the elopocephalans) and the Elopomorpha as sister to a monophyletic Clupeomorpha + Euteleostei. The relationships established for the Osteoglossomorpha, Elopomorpha, Clupeomorpha, and Euteleostei, with the Osteoglossomorpha as the most basal of the four groups, were generally accepted by most subsequent workers (see, e.g., Nelson 1994, 2006). However, as noted below, this view was challenged by Arratia (1991, 1996b, 1997a, 1998a, 1999, 2008a) and others (indeed, those doing a cladistic study of fossil and recent teleosts based on morphological characters, such as Li & Wilson 1999, agreed with the conclusions of Arratia). She gave strong reasons in analyzing the data of Patterson & Rosen (1977), and providing critical interpretations of certain homologies and new characters, for considering the Elopomorpha as the most basal group. The evidence by Patterson & Rosen supporting their phylogeny was not strong, e.g., and relevant to the work of Arratia, the elopomorphs were thought to be the sister group to clupeocephalans on the basis of uroneural elements in the caudal skeleton, and the osteoglossomorphs the sister group to elopocephalans on the basis of synapomorphies that distinguish living teleosts from *Amia*.

For example, of the 48 characters given by Patterson & Rosen (1977: p. 128-130), only character 40 ("primitively only two uroneurals, rather than three or four, extending forward beyond U2") supports the recognition of the elopocephalans. However, as Arratia has demonstrated, this character is not unique to elopomorphs plus more advanced teleosts, because it is also present in some basal teleosts such as

†*Luisichthys* (Arratia 1997a) and is variably present in adult specimens of *Hiodon* (e.g., Schultze & Arratia 1988, 1989). In addition, it is not present in primitive clupeomorphs and euteleosts (see Arratia 1997a, 1998a, 1999). Patterson & Rosen (1977) did not give any character that supported the osteoglossomorphs as being the most basal extant teleost. All their derived features (characters 36-39) are said to be shared with elopomorphs and other extant teleosts; however, they are homoplastic features that are also present in non-elopocephalans or they are not found in primitive forms (Arratia 1998a, 1999). The classification based on Patterson & Rosen (1977), fossil plesions omitted, is as follows:

Subdivision Teleostei
- Supercohort Osteoglossomorpha
- Supercohort Elopocephala
  - Cohort Elopomorpha
  - Cohort Clupeocephala
    - Subcohort Clupeomorpha
    - Subcohort Euteleostei

De Pinna (1996) found at least 27 anatomical synapomorphies to support monophyly of the recent teleosts (but not when fossils are included) when defined as the most inclusive group of actinopterygians not including *Amia* and relatives and *Lepisosteus* and relatives. The clade of all recent teleosts (the Osteoglossomorpha, Elopomorpha, Clupeomorpha, and Euteleostei) was termed the Teleocephala by de Pinna (1996). Most of the synapomorphies of teleocephalans, apart from the soft morphological changes given in de Pinna (1996), can be traced from †*Leptolepis coryphaenoides* plus more advanced teleosts of Arratia (1997a, 1999) (the so-called "true" teleosts). This indicates that most teleostean synapomorphies were gained during the Jurassic, about 199-145 million years ago, not more recently (Arratia 2004).

On some contributions of Gloria Arratia

Resolving teleost phylogeny

Ever since the mid-1980s, Gloria has been a leading figure in resolving many ichthyological questions. She is best known for major contributions in understanding early teleost evolution from a paleontological viewpoint (see also, e.g., the above brief review of "Teleostean origins, phylogeny, and classification"). Through her detailed morphological studies of fossils and extant basal teleosts with attention to ontogeny and problems of homologies, many questions have been resolved, thereby giving us a better understanding of the evolution of characters and early teleostean phylogeny (e.g., Arratia 1997a, 1999, 2004, 2008a,b). However, as she makes clear, we require a much better understanding of characters and their homology before we can erect a sound classification. She has also been and continues to be at the center of many ongoing controversies, for example, in disagreements about whether the most basal extant teleost group is the elopomorphs (Arratia 1991, 1996b, 1997a, 1998a, 1999, 2004, 2008a) as she reasons or the osteoglossomorphs as has been generally thought over the last 40 or so years (and as reviewed above and below).

Basal teleosts and their phylogenetic history – what is the most basal teleost known?

The monophyly of Teleostei when considering living taxa only has been supported or at least not refuted by numerous investigators over the last 35 years based on morphological evidence of fossil and/or living forms and on molecular data. However, when considering fossils, the definition (and hence composition) of the Teleostei has varied among authors ever since the definition by J. Müller, and the sister group of Teleostei is still unresolved and indeed disputed.

Arratia (1999, 2001) found support for the monophyly of her concept of the Teleostei in one uniquely derived character (presence of an elongate posteroventral process in the quadrate) and numerous homoplasious characters such as a mobile premaxilla and only ural neural arches modified as uroneurals. With respect to the quadrate process, Arratia & Schultze (1991: p. 67-69) and others have shown in developmental studies that the quadrate and its process is only one chondral bone, and not a compound structure resulting from fusion with the quadratojugal of primitive actinopterygians (which is a dermal bone) as suggested by some authors (e.g., Patterson 1973: p. 248). Consequently, the elongate posteroventral process of the quadrate and the quadratojugal are not homologous structures.

Amongst basal teleosts, the branching nodes of the "true" teleosts (†*Leptolepis coryphaenoides* plus more advanced teleosts) and that of †*Tharsis* plus more advanced teleosts are strongly supported by several uniquely derived characters and numerous homoplasious ones. For instance, "true" teleosts share the presence of a supraoccipital bone, extending forward in the roof of the otic region, the urohyal formed as an ossification of the tendon of the sternohyoideous muscle, the hyoidean artery piercing one or both hypohyals, an autocentrum as part of the vertebral centrum, cycloid scales, and the absence of the suprangular in the lower jaw (Arratia 1999). The node of †*Tharsis* and most advanced teleosts is supported by several uniquely derived characters, e. g., sutures between cartilage bones in the braincase retained throughout life, ossified aortic canal lost, spiracular canal absent, foramen for the glosopharyngeal nerve in the exoccipital, vertebral autocentrum with cavities for adipose tissue, and strongly constricting the notochord (Arratia 1999). Most of the 27 anatomical synapomorphies reported by de Pinna (1996) for extant teleosts are distributed in the three basal nodes of Arratia (1999: fig. 19). New characters recently discovered by Arratia (2008a) add additional support to the node of the "true" teleosts (e. g., first and last segmented-but-unbranched principal rays as leading rays of the caudal fin, basal fulcra on paired fins absent).

Arratia (2001) reviewed various hypotheses of possible sister groups of teleosts (see her paper for references): e. g., the Amiiformes (C. Patterson in 1973, H.-P. Schultze & E. O. Wiley in 1984), Lepisosteiformes (P. E. Olsen in 1984, P. E. Olsen & A. R. McCune in 1991), *Amia* and *Lepisosteus* (M. Jollie in 1984, B. B. Normark et al. in 1991, H. L. Lê et al. in 1991), †*Dapedium* and †Pycnodontiformes (B. G. Gardiner et al. in 1996), †Pycnodontiformes (J. R. Nursall in 1996), Halecomorphi (L. Grande & W. Bemis in 1998), †Pachycormiformes and †*Dapedium* (Arratia 1999), and †Aspidorhynchiformes etc. (Arratia 1999). As Arratia (2001) notes, the lack of morphological evidence to support any fossil group as the sister group of teleosts remains one of the biggest challenges for ichthyologists. The concept of Teleostei sensu Patterson (1977) and Patterson & Rosen (1977), with halecomorphs as the sister group and †Pachycormiformes and †Aspidorhynchiformes at the base, was questioned by Arratia (1997a, 1999, 2000, 2001) who suggested that †*Pholidophorus bechei* (note, neither †Pholidophoriformes nor †*Pholidophorus* is monophyletic) is the basal taxon. The resulting classification based on the cladogram of Arratia (2001: p. 771) and reproduced in Arratia (2004: p. 291) is shown below.

Lepisosteus
Amia
Teleosteomorpha (new term, Arratia 2001)
Unknown stem fossils
Teleostei
†*Pholidophorus* (based on Arratia 2000, 2001)
†*Leptolepis*
†Varasichthyidae
†Ichthyodectiformes
Teleocephala (new term, de Pinna 1996)
Elopidae
More advanced teleosts

Arratia (2001) introduced the term Teleosteomorpha for the taxon including the Teleostei (with †*Pholidophorus* as the primitive sister taxon to the remaining teleosts) and stem-based fossils [excluding the Halecomorphi (*Amia* and relatives) and the Ginglymodi (*Lepisosteus* and relatives)] and used the term Teleocephala of de Pinna (1996) for the included taxon, a crown group, covering everything sister to the †Ichthyodectiformes. Arratia (2004) further explored this concept of relationships and gave an insightful evaluation of our understanding of halecomorph and teleost phylogeny. This work nicely shows what we know and what remains uncertain. Recently, and based in a detailed study of fin rays and fulcra of basal actinopterygians and teleosteomorphs, Arratia (1998a: fig. 31) interpreted †Pachycormiformes, †Aspidorynchiformes, and several so-called †Pholidophoriformes as potential stem-group teleosts, at the base of the Teleosteomorpha.

Some controversy exists because the ages from the fossil record noted in Arratia (2004) are very different from the divergence times proposed by molecular papers. It will be a challenge for the molecular biologists to find some explanation for their proposed times of divergence because the fossil record for the basal teleosts (most of them Jurassic) is reasonably strong for a Middle-Late Triassic origin.

The osteoglossomorph-elopomorph question – which is the more primitive extant teleost taxon?

There is a major difference of opinion in what is the most primitive extant teleost taxon as noted above under "Teleostean origins, phylogeny, and classification" and as shown below in the text table.

After Patterson & Rosen (1977)	After Arratia (1997a, 1999)
Osteoglossomorpha	Elopomorpha
Elopomorpha	Osteoglossomorpha
Clupeomorpha	Ostarioclupeomorpha
Euteleostei (including Ostariophysi)	Euteleostei

Arratia (1991, 1996b) challenged the view that osteoglossomorphs are more primitive than elopomorphs on the grounds that the caudal skeleton of *Elops* is interpreted to be more primitive than that of the osteoglossomorphs. Subsequent detailed work of Arratia (1997a) further supported the view that elopomorphs are the living sister group of all other living teleosts. However, this in turn has been challenged by Patterson (1998) (but see the rebuttal by Arratia 1998a and 1999, 2004, 2008a) and also by molecular data in the work of Inoue et al. (2003). However, molecular studies give contradictory results. For example, nuclear markers used by Hoegg et al. (2004) weakly supported the Elopomorpha and Osteoglossomorpha forming a monophyletic group, but did not clearly reject the hypothesis that osteoglossomorphs are basal to elopomorphs. Li et al. (2008), although, e.g., finding a monophyletic Ostarioclupeomorpha, could not differentiate between either the elopomorphs and osteoglossomorphs as being the more basal taxon, and, in examining three species, they did not find support for a monophyletic Elopomorpha.

According to Arratia (1997a, 1999: p. 324) the position of the elopomorphs at the base of the teleocephalans is supported by osteological and soft anatomical characters. For example, primitively in elopomorphs and in more advanced teleosts the hyoidean artery pierces both hypohyals, there is an endoskeletal basihyal present, the first uroneural reaches preural centrum 2, and the craniotemporal muscle is present as well as accessory nasal sacs. The position of osteoglossomorphs plus more advanced teleosts is supported by several synapomorphies, as for instance, the antorbital branch of the infraorbital sensory canal is not enclosed by the antorbital bone, the posterior opening of the mandibular sensory canal is placed laterally on the angular portion of the lower jaw, and a gular plate is absent (for details and more characters see Arratia 1999). Four characters recently described by Arratia (2008a) give additional support to the placement of the osteoglossomorphs, not elopomorphs, as sister of more advanced teleosts (e.g., the complex first pectoral ray is absent, so that the first pectoral ray is formed only by its hemilepidotrichia, and the fringing fulcra are absent on both lobes of caudal fin in contrast to fossil basal teleosteomorphs and basal elopomorphs).

There are thus challenges in the two main hypotheses presented, but current evidence seems to favor the Elopomorpha as being the most primitive extant teleost taxon as presented by the works of Arratia. Her hypothesis is also supported by morphological studies of both fossil and recent teleosts by Shen (1996), Li (1996), Zhang (1998), Li & Wilson (1999) and by morphological studies of recent forms by Diogo & Abdala (2007: p. 506) and Diogo (2007), based on different sets of characters. Arratia (2008b) in the volume for Peter Forey's retirement has new information that provides a better understanding of basal teleosts and of their phylogenetic history. The object of the paper was not to test the phylogenetic position of elopomorphs, but in a new matrix and with †Crossognathiformes included in the phylogenetic analysis, the elopomorphs again appear in a basal position with respect to the osteoglossomorphs.

In addition to cladistic arguments by Gloria based on morphology that elopomorphs are sister to the remaining teleosts (Osteoglossomorpha, Ostarioclupeomorpha, Euteleostei), they are also known earlier in the fossil record as noted in Arratia (2004), with the oldest elopomorph known from the Kimmeridge Stage of the Late Jurassic (about 155 million years ago), but the oldest osteoglossomorph fossil is known from the Early Cretaceous.

We look forward to the results of future molecular work and to studies with a large enough diversity of taxa designed to actually test both hypotheses – that elopomorphs are more basal than osteoglossomorphs or vice versa.

Ostarioclupeomorphs versus otocephalans

As an aside, there has been growing evidence that the sister group of the clupeomorphs are the ostariophysans and this is reflected in the above text table under Arratia (1997a, 1999) (i.e., Arratia's Ostario-

clupeomorpha includes the Clupeomorpha + Ostariophysi). The name used here for this subdivision, Ostarioclupeomorpha (a taxon-based name), is from page 170 of the 1996 doctoral dissertation of Gloria Arratia, where evidence for the relationship was presented (published in Arratia 1997a: p. 155); the widely used synonym, Otocephala (an apomorphic-based name), was first published by Johnson & Patterson (1996). The removal of Ostariophysi from Euteleostei is a major change; however, as she notes, the highly diversified Euteleostei is still a poorly supported group with many characters that are homoplasious and with little knowledge about the basal members.

Systematics of the †Crossognathiformes

Arratia (2008a) has changed our ideas about the systematics of the Cretaceous †Crossognathiformes (e.g., †*Crossognathus sabaudianus*), most recently thought to be the primitive sister group of Clupeiformes and Eutelostei. She provided strong evidence from a detailed morphological study, consideration of homologies, and cladistic analysis, that the Late Jurassic marine family †Varasichthyidae (e.g., †*Varasichthys ariasi*) known from Chile and Cuba is the sister group of the other †Crossognathiformes (now also including another Jurassic taxon, †*Chongichthys*). †Crossognathiformes should now be considered a basal teleost group ranging from the early Late Jurassic to the end of the Cretaceous.

Some other contributions of Gloria Arratia

Contributions on living fishes. In addition to Arratia's systematic work on fossil fishes, some of which are mentioned above, she has also made fundamental contributions to the taxonomy, systematics, and evolution of living fishes. She has, for example, published extensively on South American percichthyids (e.g., Arratia 1982) and catfishes, including co-editing a book on this order (Arratia et al. 2003). Her contribution to the knowledge of catfishes includes revision of previously described species, description of new species, and extensive osteological studies of Diplomystidae (e.g., Arratia 1987, 1992), traditionally considered the most basal taxon and with the most plesiomorphic characters among siluriforms. She has also provided information on the soft anatomy (e.g., Arratia & Huaquín 1995), chromosomes, and ecological aspects of diplomystids. She has made major contributions to the knowledge of trichomycterid catfishes, mainly the species in temperate South America, describing new species and genera, and providing detailed morphological descriptions (e.g., Arratia et al. 1978, Arratia & Menu-Marque 1984, Arratia & Huaquín 1995, Arratia 1998b). She provided the first description of the sensory canal system and skin of diplomystids and loricarioids, systematically important basal catfishes, and she also identified possible homologues in the sensory canal system and its pores. Her biogeographical papers on the Austral versus Neotropical regions in South America (Arratia et al. 1985, Arratia 1997b) are additional important contributions.

Contributions on characters and homologies. One of Gloria's main contributions has been the search for new characters. Phylogenetic hypotheses of actinopterygians based on morphological characters have primarily dealt with cranial osteology, and she has extended this character base in her research. In searching for new characters, she has studied the ontogeny of elements of the suspensorium in various actinopterygians and proposed several synapomorphies at different phylogenetic levels, including the posteroventral process of the quadrate as a teleostean synapomorphy (Arratia & Schultze 1991). A paper on the urohyal (Arratia & Schultze 1990) and its evolutionary transformation in siluriforms was also a successful search for new characters (see Wiley 2008), as was a monograph on the ontogenetic transformation of the suspensorium, also in siluriforms. In a series of papers involving vertebrae, Arratia (1991), Arratia & Schultze (1992), and Arratia et al. (2001) proposed that the notochord in fishes plays a fundamental role in the formation of the vertebral centra. These studies have been influential, and there are different groups of researchers (see e.g., Grotmol et al. 2003, 2005, Nordvik et al. 2005) investigating the notochord and its role in vertebral patterning of vertebrates. Several publications have led to a better understanding of the diversity of the caudal skeleton in fishes including ontogenetic studies and histology of the vertebrae (e.g., Schultze & Arratia 1988, 1989, Arratia & Schultze 1992), and critically analyzing the variability of the caudal skeleton (e.g., Arratia 1983, 1991, 1997a). One major goal of these papers was to study and discover homologous structures in the caudal fin. Her studies have shown that the "ural centra 1 and 2" in adult teleosts are not homologous and that the "epural 1 and the uroneural 1" are not homologous among teleostean subgroups. These major questions of homology were solved

with daily ontogenetic series from different teleosts and interpreting the caudal skeleton in a polyural fashion in order to understand the origin, development, and fusion and/or deletion of structures during growth. Currently, two major "Tree of Life" projects, the Cypriniformes and the Euteleostei, are following Arratia and Schultze's approach in their studies of the caudal skeleton. A presentation of G. Arratia, M. Coburn, and P. Mabee at the XII European Congress of Ichthyology, 13 September 2007, showed that there are different centra origins in the caudal skeleton of ostariophysans and clupeomorphs. The differences are systematically important and support the hypothesis by her and Hans-Peter Schultze that the ural centra present in teleosts have different origins. Discovering how the centra are formed, as well as the epurals and uroneurals, will help to solve the problem of homology of these elements among teleostean subgroups. Recent studies on the fin rays of actinopterygians provide new insights on the evolution of these elements and of the homologies, and they provide new definitions and new landmarks for identifying elements of the fins as well as new characters supporting the monophyly of Teleostei and the position of elopomorphs as the basal taxon among Teleocephala (Arratia 2008a). Gloria has not restricted her morphological studies and exhaustive analyses of potential homologous structures to teleosteomorphs, but she has occasionally included sarcopterygians and basal actinopterygians. Understanding homologous structures, and consequently synapomorphies, has been one of the main goals of many of her publications. For example, in studies of patterns of diversity of basal actinopterygians (e.g., Cloutier & Arratia 2004) the influence on phylogenetic hypotheses of e.g., missing data, deleting poorly known or ambiguous characters, and deleting incomplete taxa was assessed.

Contributions to symposia and their publication and editorial duties. Gloria is also well known as the Editor-in-Chief of the volumes Mesozoic Fishes and spearheading four conferences mentioned under "Publication record" at the end of the Introduction leading to the books published by Verlag Dr. Friedrich Pfeil. She is an associate editor of a few journals (e.g., Fossil Record). In addition, she has reviewed a large number of manuscripts for many journals and books in the last ten years. Gloria was the main organizer of four of the six "Special Symposia on Fishes" in the last 28 year history of symposia in meetings of the Society of Vertebrate Paleontology. The first in 1997 was on the "Actinopterygian fishes. Progress in understanding their relationships"; the second in 1999 on "Fish heads. Evolutionary patterns"; the third in 2002 was on "Recent advances in the origin and early radiation of the vertebrates"; and the fourth in 2008 was on "Fossils and the evolutionary patterns of ostariophysans, one of the largest vertebrate clades". These symposia included a broad analyses of morphological systems, characters, and phylogenies in fossils and recent organisms. They lead to a better understanding of fish groups as evolutionary entities without barriers of time. She has sought to have better communication between morphological and molecular researchers. Participants agree that Gloria motivates people and her optimism and enthusiasm spreads throughout a group. Ichthyologists owe her a debt of gratitude for her intellectual contributions, vision, and superb organizational abilities in holding conferences and publishing their papers, and in training young and old ichthyologists. What a fascinating history she has had!

This remarkable Chilean scientist is indeed one of the outstanding ichthyologists in systematics and morphology in the world and the world leader in studies of basal teleosts. The ichthyological community are pleased that Gloria continues to be active and will no doubt continue to make valuable contributions.

Acknowledgments

I am immensely grateful to Gloria Arratia, Hans-Peter Schultze, and Sarah Rages for providing much help and information for this paper. Four reviewers gave many valuable suggestions to the manuscript. I thank all individuals who helped make the 2007 symposium honoring Dr. Gloria Arratia a success. This symposium of the American Society of Ichthyologists and Herpetologists (ASIH), forming the basis for this volume, was held in St Louis, Missouri, and was organized by Hans-Peter Schultze, Mark Wilson, and myself, Joe Nelson.

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The origin and the phylogenetic interrelationships of teleosts have been controversial subjects ever since Greenwood, P. H., Rosen, D. E., Weitzman, S. H. and Myers, G. S. in 1966 presented a revision of teleost phylogeny. Different taxa (*Amia*, *Lepisosteus*, *Amia* + *Lepisosteus*, †Pycnodontiformes, †*Dapedium*, †Pachycormiformes, and others) have been proposed as the sister group of teleosts. Tremendous advances have occurred in our knowledge of Neopterygii, basal to teleosts, and in their major component the teleosts over the past 40 years. Many new key fossils have been studied, and many extant teleost clades have been traced back to the Jurassic in detailed studies by Gloria Arratia in 1987, 1996, and 2000. In addition to new fossils, a large number of new morphological and molecular characters have been incorporated in recent phylogenetic analyses, adding to our arsenal of approaches. This book gives a modern view of these approaches. It includes a compilation of synapomorphies of numerous teleostean taxa with a new proposal of their classification, a proposal that pycnodonts are the fossil sister group of teleosts, a phylogeny based on mitochondrial genome sequences, separate analyses of basal teleostean taxa (Osteoglossomorpha, Clupeiformes, Gonorynchiformes, Cypriniformes, Characiformes, Siluriformes, Salmoniformes, Esociformes) and the euteleostean Aulopiformes, karyological studies of Cyprinodontidae, and morphological analyses of the posterior part of the neurocranium. A biography of Gloria Arratia is also presented.

The book represents contributions to the symposium "Origin and phylogenetic interrelationships of teleosts" sponsored by the American Society of Ichthyologists and Herpetologists (ASIH) and organized by the three editors of this volume and held at the Society's annual meeting in St. Louis, Missouri, on 14 July 2007. At the same meeting, Gloria Arratia was honored with the Robert H. Gibbs, Jr. Memorial Award, 2007, for her outstanding contributions to systematic ichthyology. The volume presents the current state of phylogenetic knowledge of the origin of teleosts and the interrelationships of teleost groups, both key issues in fish systematics, based on both morphological (of extant and fossil taxa) and molecular evidence. The many contributors to the volume present and evaluate progress in studying both characters and taxa and in establishing databases (morphological and molecular) that will be of use in future.

ISBN 978-3-89937-107-9 www.pfeil-verlag.de