Int. J. Dev. Biol. 47: 189-192 (2003)

Developmental biology in Ecuador: a 30-year teaching experience

EUGENIA M. DEL PINO*

Departamento de Ciencias Biológicas, Pontificia Universidad Católica del Ecuador, Quito, Ecuador

ABSTRACT Developmental biology has been taught at the Pontificia Universidad Católica del Ecuador, in Quito for 30 years by the author. The experience of teaching development is described within the broader context of science in Latin America. It is recognized that developmental biology is poorly represented in research and teaching in this part of the world. The teaching of developmental biology to Ecuadorian students contributes to their intellectual training, by helping them to integrate concepts derived from various branches of biology. Moreover, the highly conserved molecular mechanisms of development provide extraordinary examples of the unity of biology, and many complex biological processes can be more easily grasped when studying embryos.

KEY WORDS: *South America, Ecuador, developmental biology teaching*

Background Information

Scholarly Interests of the Author

The author is interested in frog development. In particular, she studies the reproduction and development of *Gastrotheca riobambae* (Hylidae), a local marsupial frog that inhabits the northern valleys of Ecuador. In addition, the author has analyzed the strategies of oogenesis, egg size, and reproduction in most of the approximately 60 species of marsupial and related hylid frogs. In several marsupial frogs, she and her collaborators discovered previtellogenic oocytes that contain thousands of nuclei instead of just one germinal vesicle. This type of oogenesis was named multinucleated oogenesis. Moreover, embryos of the marsupial frog *Gastrotheca* deviate greatly from the *Xenopus* pattern of development. Her current interests center on studying the expression of dorsal development markers in *Gastrotheca.* Research interests include the study of early development in frogs and fish with modified reproductive patterns, such as the frog *Colostethus machalilla* (Dendrobatidae) and the native viviparous teleost fish *Priapichthys panamensis* (Poeciliidae).

Representative Publications

The citation listed below is to a textbook of developmental biology written in Spanish. Its contents were derived from the lecture notes of the author. This book is now outdated and used only as a reference for material not covered in current textbooks, such as oogenesis in marsupial frogs (del Pino, E.M., 1989b). See also the "References" section at the end of this paper for other publications by the author.

Biographical Information

Thirty years ago, immediately after having completed a Ph.D. degree in Biology at Emory University (Atlanta, GA, U.S.A., 1972), I began teaching developmental biology in Ecuador. My studies at Vassar College (Poughkeepsie, NY) and Emory University were sponsored by the Latin American Scholarship Program of American Universities (LASPAU), an organization that contributes to the teaching of science in Latin American universities. By accepting the LASPAU fellowship, I made a commitment early in my scientific career to teach and conduct academic work in an Ecuadorian setting. However, I chose developmental biology as my field—an area which to date is poorly represented in Latin America (del Pino, 1998). In fact, the Latin American Network of Biological Sciences (RELAB) recognizes that high priority research fields such as molecular biology and developmental biology are underrepresented in Latin America and has further concluded that local, regional and international efforts need to be concentrated in these areas of research to facilitate the scientific advancement of the Latin American region (1994 RELAB symposium "Present and future themes in biological research in Latin America," reviewed in this issue).

My thesis advisor was Asa A. Humphries Jr., who was a student of Gerard Fankhauser, an embryologist trained in the classical

Abbreviations used in this paper: kDa, kilodaltons; LAP2, lamina-associated polypeptide 2; LASPAU, Latin American Scholarship Program of American Universities; PUCE, Pontificia Universidad Católica del Ecuador; RELAB, Latin American Network of Biological Sciences; SDS-PAGE, sodium dodecyl sulfate-polyacrylamide gel electrophoresis.

***Address correspondence to:** Dr. Eugenia M. del Pino. Pontificia Universidad Católica del Ecuador, Departamento de Ciencias Biológicas, Avenida 12 de Octubre y Patria, Apartado 17-01-2184, Quito, Ecuador. Fax: +593-2256-7117. e-mail: edelpino@puce.edu.ec

0214-6282/2003/$25.00

Printed in Spain
www.ijdb.ehu.es

Fig. 1. Four participants in the 1999 Developmental Biology Seminar working with the author on a protein gel. *From left to right: Oscar Pérez, Eugenia M. del Pino, María-Eugenia Ávila, Fabián E. Sáenz and Federico D. Brown, are preparing protein samples to be processed by SDS-PAGE and immunoblotting.*

school of embryology (Fankhauser, 1972). My dissertation dealt with the role of the egg jelly coats of the *Xenopus* egg in the union of gametes (del Pino, 1973). I was highly motivated to study animal development, and when I returned to Ecuador after completion of my training, I wanted to continue doing experimental work. In Ecuador, I had no access to the model organism, the frog *Xenopus*. I therefore searched for an accessible frog to use for my studies. I found it in the gardens of the university; it is a "marsupial" frog, the hylid *Gastrotheca.* At my request, my former advisor, Asa A. Humphries, Jr. searched the literature. He wrote me a letter in which he explained that nothing was known about the development of the marsupial frogs. He added that I could make a successful career by studying these frogs. I followed his advice, and most of our scientific work has concentrated on questions of marsupial frog development (del Pino, 1989a).

Thirty years ago, because of my recently acquired expertise, the Pontificia Universidad Católica del Ecuador (PUCE) in Quito, introduced an "Embryology" course as a core requirement for biology students. Originally we trained high school biology teachers. Since 1976, the PUCE has offered a degree in Biology after eight semesters of study and submission of a thesis based on original research. Developmental biology continues to be a core subject. It is a five-credit course given in the 5th semester. Students attend three hours of lecture and one three-hour laboratory session each week. The enrollment is approximately 25 students. I taught both the lectures and laboratory sessions for many years, but recently other members of the faculty have taken over the laboratory sessions. Additionally, I offer three-credit elective seminars on developmental biology to students in the 5th and 6th semesters of their studies. Four to eight students may enroll in these elective courses. Developmental biology is not immediately applicable for the future employment of most Ecuadorian biologists. However, I consider that an introduction to this important area of biology is valuable for students all over the world because the study of developmental biology allows the integration of concepts derived from various branches of biology, including ecology and evolution. Moreover, the highly conserved molecular mechanisms of development provide extraordinary examples of the unity of biology. In addition, complex structures, such as the brain, can be more easily understood when studying embryos.

Developmental Biology Lecture Course

The Early Years - Traditional Teaching

My teaching career began in 1972, immediately after I returned from the USA. I was invited to give an intensive seminar on embryology to advanced students from the Universidad Estatal de Guayaquil. I remember spending most of the day preparing for my daily two-hour lecture by reading Davidson (1968). I had never encountered another group of students with such an intense interest in what I was explaining. I also realized that my lectures were quite strange to them. Immediately after this, I started to teach embryology in Quito (An outline of the contents of the 2001 Development course is included in Table 1).

I discovered that three textbooks of embryology had been translated into Spanish: Brachet (1975); Balinsky (1978); and Patten (Carlson, 1990). I used these books as references for my lectures. I have also benefited from the collaboration of many colleagues who have donated textbooks to me for my teaching, including favorite textbooks such as Wolpert *et al.* (1998) and Gilbert (2000). At first, my students depended heavily on the notes that they took during lectures. My lecturing method included extensive use of the blackboard, and I repeated the main ideas more than once, using different words. As a result, however, many inaccuracies were incorporated into the students' notes and, unfortunately, into their learning.

My lecture notes were short annotations, which I normally discarded after each session. However, in 1985 I acquired a personal computer, which allowed me to have neatly organized lecture notes. The students began to photocopy my lecture notes. Soon, I was preparing copies of the lecture notes as handouts to give to students before each lecture. Instead of freely talking about the subject, I learned to adhere to the lecture notes. The "learning" results were excellent. Students concentrated on listening to the explanations of the text that they had in front of them. This method facilitated the transmission of accurate information and more active participation of students in the classroom. For the first time in my teaching career, I kept my lecture notes. Each year, I improved my class notes, and in

TABLE 1

OUTLINE OF THE DEVELOPMENTAL BIOLOGY LECTURE COURSE[1]

Theme	Description
1	Introduction to developmental biology: Basic concepts
2	Axis formation in the frog and other vertebrates
3	Germ layers and the vertebrate body plan
4	Development of the mesoderm and endoderm
5	Neural development
6	Cleavage patterns and blastula formation in vertebrates
7	Vertebrate gastrulation and the formation of the neural tube
8	*Drosophila* development
9	Germ cells and fertilization
10	Development and evolution

[1] Based in the 2001 Developmental Biology semester course, with three lectures and one 3-hour laboratory session per week (see the outline in Table 2). Wolpert *et al.* (1998) was used as textbook. Grading system: The university requires three preliminary grades and a final examination. My tests consist of four essay questions. Each answer must be no more than one page. Class presentations are also graded.

1989 the university printed my textbook of animal development (del Pino, 1989b). I used this textbook successfully for several years.

Recent Years - Student Participation

During my career, I have witnessed the expansion of the field of developmental biology. Because it is growing at such a fast pace, textbooks become outdated quickly! I have switched to the use of textbooks in English for the teaching of developmental biology, and I have also changed my teaching method. I have reduced my own lecturing. Instead, I complement and supplement student presentations. I also encourage discussion. I may assign a group of two to four students to read and prepare the material that we will cover in a given session. They can consult with me about any doubts that they may have. Students make an oral presentation of the assigned material, which corresponds to a few pages of the textbook, for example Wolpert *et al.* (1998). Students often prepare overhead transparencies of good illustrations in this and similar books, or they bring illustrations that they have found on the Internet. Additionally a few students have acquired copies of the textbook. There is normally excellent class participation. Students learn to read and understand new material, a skill that should be useful in their future professional life. Moreover, students acquire the experience of talking in front of a group of people. We adhere to the textbook, avoiding the introduction of errors into their notes. The main disadvantage is that these textbooks are in English. However, our students have English reading ability.

TABLE 2

OUTLINE OF THE DEVELOPMENTAL BIOLOGY LABORATORY COURSE[1]

Session	Student presentations based on textbooks and material available on the Internet	Practical experience and videos
1	Introduction, given by the instructor	Video of amphibian development by H. Grunz[2]
2	Development of the chick	Dissection of an unfertilized hen egg
3	Development in nematodes and mollusks	Observation of 18-h living chick embryos and of 18-h prepared slides of the avian embryo
4	Development of echinoderms, ascidians and *Dictyostelium*	Observation of 24-h living chick embryos and of 24-h prepared slides of the avian embryo
5	Development in frogs	Observation of 33-h living chick embryos and of 33-h prepared slides of the avian embryo. Video of *Xenopus* development by David Shook[3]
6	Axis formation in frogs	Observation of 48-h living chick embryos, and of 48-h prepared slides of the avian embryo. Isolation of animal caps of the *Xenopus* blastulae and experiment on embryonic induction by vegetal cells
7	Development in the marsupial frog *Gastrotheca*	Video on embryonic cell affinity (Third part of H. Grunz video[2]). Observation of prepared slides of frog development
8	Development in the zebrafish	Student projects: the frog
9	Development in *Drosophila*	Student projects: *Drosophila* and insects
10	Development in mammals.	Student projects: the mouse
11	Sexual determination and the Bidder's organ in *Bufo*	Student projects: development in cichlid fish
12	Development in plants	Student projects: the snail
13-15	Presentations and discussion of articles on development. Each student chooses an article and analyzes it with the help of the instructor before this presentation.	

[1]Based on the 2001 developmental biology course. The course includes 1 three-hour laboratory session and three hours of lecture per week (Table 1). [2]Information about the video by H. Grunz can be found in his Web site: http://www.uni-essen.de/zoophysiologie/. [3]Time-lapse video microscopy of *Xenopus* gastrulation to neurulation, made by David Shook in the laboratory of Ray Keller, funded by the NIH. This video can be downloaded from the D. Shook Web site: http://faculty.virginia.edu/shook/ShowMovies/index.htm

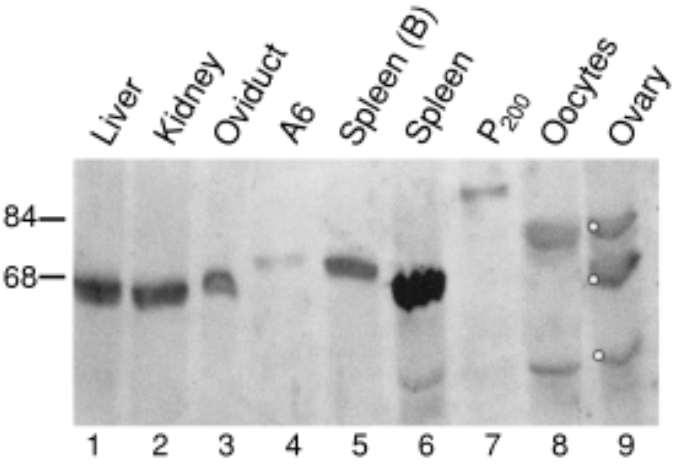

Fig. 2. The immunoblot produced by students during the 1999 developmental biology seminar. *Each participant prepared proteins from one or two frog tissues and each person loaded their samples into the gel. The gel and corresponding immunoblot were a joint class project. The proteins were separated by SDS-PAGE with 10% acrylamide and immunoblotted with a LAP2-specific antibody. The blot compares LAP2 expression in* Eleutherodactylus unistrigatus*, a frog with direct development (lanes 1-3, 6, 8 and 9, with the spleen of* Bufo marinus *(spleen B, lane 5) and* Xenopus *(lanes 4 and 7), which lay eggs in water. A6 corresponds to* Xenopus *kidney cells and* P_{200} *are* Xenopus *egg membranes. Molecular masses of reference proteins are given (in kDa). This illustration was published as Fig. 3A in del Pino* et al. *(2002). See this article for further information about LAP2 expression in fish and amphibians.*

Developmental Biology Laboratory Sessions

To enhance the laboratory sessions, my colleagues have made extensive use of the excellent Web sites now available on the subject of development. Students are assigned to search for information, for example, about a model organism. They present their findings during the laboratory session. The excellent images that they find on the Web are a valuable complement to the laboratory exercises. Additionally, we use a videotape on amphibian embryogenesis and one about gastrulation in *Xenopus*. These videos were kindly provided by Horst Grunz (University of Essen, Germany; http://www.uni-essen.de/zoophysiologie/) and David Shook (University of Virginia; available by download at http://faculty.virginia.edu/shook/ShowMovies/index.htm), respectively.

Two different activities are conducted during each three-hour laboratory session. The first is a presentation of a model organism for development, based on textbook descriptions and the excellent material now available in the Internet. Groups of two to three students give these presentations, and the instructor adds additional information. Other activities include the study of frog and chick embryos in sections. Students often observe living chick embryos. Federico D. Brown taught the laboratory sessions in 2001 (Table 2).

In addition, as in the year 2001, students may be required to conduct an independent research project. Since we have only limited resources, these projects are often quite modest, and not very successful. In the 2001 course, four to five students conducted each project (Table 2). They chose an organism, went to the field to collect samples, and observed the developmental processes. Students analyzed the morphology of development of two different frog and fish species. Additionally, they analyzed the gonads of frogs, mouse, and fish. Other students observed eggs in *Drosophila*, a moth, and a snail. The results were written up in the style of a scientific report, and each group of students also gave an oral presentation on the subject. For these presentations, the students made extensive use of resources found in the Internet.

Developmental Biology Seminar Course

I greatly enjoy teaching developmental seminars to small groups of students. During each session, half of the time is used for the presentation of assigned textbook chapters, such as from Gilbert (2000). The method is the same as that described in the lecture course. We cover two to three chapters of this book during the semester. During the second part of each session, we analyze recent literature, choosing papers that are not necessarily related to the assigned chapters. First, we read and understand the title and abstract of the article that we are studying. We then analyze the figures and tables with reference to the results and the abstract. Students really enjoy learning to read a paper analytically. In addition, students participate in experimental work that is being conducted in my laboratory. Their results are presented as a scientific report, written in the format of a thesis. The availability of developmental literature on the Internet is a valuable tool, as our library does not subscribe to biological journals. Students can now access research articles that are freely available; for example, the journal *Development* allows free access to older articles on its Web site.

The 1999 seminar course was particularly successful because the five participants not only learned new methodologies (Fig. 1), but also became particularly interested in development. Later, all of them conducted research and prepared theses in developmental biology with my guidance. Just before this course started, SDS-PAGE and immunoblotting methods were implemented in my laboratory, thanks to help from Georg Krohne (University of Würzburg, Germany) and his student Carmen Lang. She used these methods to study lamina-associated polypeptide 2 (LAP2) expression in cells of the marsupial frog *Gastrotheca*. I decided to demonstrate these techniques to the seminar participants, and in this way to improve my confidence with these methods. In the seminar, we analyzed the article by Lang *et al.* (1999), then in press, among others. This article provided the background for our experimental work. The course participants were thrilled to have the experience of running a gel (Fig. 1). Each student loaded one or two gel lanes in the single gel that we ran during the course. The proteins were transferred to a nitrocellulose membrane and immunoblotted with a LAP2-specific antibody (Fig. 2). The results were excellent, and as themes for their theses, the entire class studied LAP2 expression patterns in different fish and amphibians. Later, this collaborative work was published (del Pino *et al.,* 2002), including the first blot, produced during the course (Fig. 2). Similarly, some students who participated in these seminars have at other times done their undergraduate theses in developmental biology. Their collaboration has been welcome, for it has advanced our scientific work

Developmental Biology's Future in Latin America

Not only the teaching of developmental biology, but also research in this field needs to be further emphasized in Latin America. In particular, the rich biodiversity of the region can provide alternative organisms for the analysis of development. Those studies may complement the information obtained from other model organisms, such as the frog *Xenopus.* Advancement of research and teaching of development can be further strengthened by international collaboration. Although developmental biology is not immediately applicable in Ecuadorian society, I believe that the opportunities for intellectual training it provides are important for scientists generally. That intellectual training includes the ability to interrelate concepts derived from various branches of biology and the knowledge of the highly conserved molecular mechanisms of development.

Acknowledgements

I thank I. Alcocer and F. D. Brown for introducing Internet tools into the teaching of Development laboratory sessions. I am grateful to Horst Grunz and David Shook for providing us with copies of their videos. Finally, I wish to recognize the help of the Pontificia Universidad Católica del Ecuador for allowing me to teach developmental biology in Ecuador. I thank G. M. Malacinski and S. Duhon for critical reading of the manuscript.

References

BALINSKI, B.I. (1978). *Introducción a la embriología* (translation of the third edition). Ediciones Omega, Barcelona.

BRACHET, J. (1975). *Introducción a la embriología molecular*. H. Blume ediciones, Madrid.

CARLSON, B.M. (1990). *Embriología básica de Patten*. 5th edn. Interamericana. McGraw-Hill, Mexico.

DAVIDSON, E.H. (1968). *Gene activity in early development*. Academic Press, New York.

DEL PINO, E.M. (1973). Interactions between gametes and environment in the toad *Xenopus laevis* (Daudin) and their relationship to fertilization. *J. Exp. Zool.* 185: 121-132.

DEL PINO, E.M. (1989a). Modifications of oogenesis and development in marsupial frogs. *Development* 107: 169-187.

DEL PINO, E.M. (1989b). *Desarrollo embriónico temprano en los animales*. Ediciones de la Pontificia Universidad Católica del Ecuador, Quito.

DEL PINO, E.M. (1998). Basic research and university training: Developmental biology in Latin America. In *Wissenschaftleraustausch und Entwicklungszusammenarbeit vor der Jahrtausendwende*. (Ed. A. von Humboldt Foundation) Nomos-Verlag, Baden-Baden, pp. 211-214.

DEL PINO E.M., SÁENZ F.E., PÉREZ O.D., BROWN F.D., ÁVILA M.-E., BARRAGÁN V.A., HADDAD N., PAULIN-LEVASSEUR M. and KROHNE G. (2002) The LAP2 (lamina-associated polypeptide 2) expression in fish and amphibians. *Int. J. Dev. Biol.* 46: 327-334.

FANKHAUSER, G. (1972). Memories of great embryologists. *Am. Sci.* 60: 46-55.

GILBERT, S.F. (2000). *Developmental Biology.* 6th edition. Sinauer Associates, Sunderland.

LANG, C., PAULIN-LEVASSEUR, M., GAJEWSKI, A., ALSHEIMER, M., BENAVENTE, R. and KROHNE, G. (1999). Molecular characterization and developmentally regulated expression of *Xenopus* lamina-associated polypeptide 2 (XLAP2). *J. Cell Sci.* 112: 749-59.

WOLPERT, L., BEDDINGTON, R., BROCKES, J., JESSELL, T., LAWRENCE, P. and MEYEROWITZ, E. (1998). *Principles of Development*. Current Biology Ltd., London.