

CHAPTER 21

Amphibians of Timor-Leste: A Small Fauna under Pressure

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I. INTRODUCTION

The Democratic Republic of Timor-Leste, also known as East Timor (Fig. 1), became Southeast Asia's newest country in 2002, after over 400 years as Portugal's most remote colony, followed by 24 years of Indonesian occupation. Knowledge of this history, particularly as it relates to the exploitation and treatment of the environment, is instrumental and instructive when considering the challenges faced by its amphibian fauna.

The country consists of roughly the eastern half of Timor Island (Fig. 1), the largest island of the Outer Banda Arc in the Lesser Sunda Archipelago. It is a mountainous and geologically heterogeneous landmass at the convergence of the Australian and Eurasian tectonic plates (Bowin *et al.* 1980; Breen *et al.* 1989; Keep *et al.* 2003). The territory of Timor-Leste includes the Oecusse exclave, 60 km by air to the southwest of mainland Timor-Leste along the Savu Sea and surrounded by Indonesian West Timor, as well as the corallogenic Jaco Island at the country's eastern tip and Atauro Island, a small, similarly heterogeneous landmass, which geographically belongs to the geologically distinct Inner Banda Arc.

With the exception of specimens of rhacophorid frogs (genus *Polypedates*) collected by Salomon Müller and Heinrich Macklot in the 1820s, reports of the frogs on Timor came mainly from the survey of collections by van Kampen (1923) and from the expedition by Malcolm Smith in 1924 (Smith 1927). As a consequence, our knowledge of the amphibian fauna of Timor-Leste is still emerging (e.g., Kaiser *et al.* 2011) and it appears that a considerable amount of alpha taxonomy is required to form a more complete assessment of the amphibian diversity on Timor Island.

Fig. 1. Map of Timor-Leste.



II. AMPHIBIANS OF TIMOR-LESTE

The diversity of frogs in Timor-Leste comprises a small subset of Sunda Shelf taxa occurring to the east of Wallace's Line (e.g., *Fejervarya*, *Polypedates*) as well as a similarly small subset of Sahul Shelf taxa occurring to the west of Lydekker's Line. Due to the lack of research on the frogs of Timor Island, and in the area of Timor-Leste in particular, the exact species composition is not yet known. The following basic descriptions are based on the present authors' observations during Phases I–III of ongoing field research in Timor-Leste, as well as on the reports cited.

A. *Duttaphrynus melanostictus* (Bufonidae)

The only species of toad in Timor-Leste, the Asian or Black-spined toad *Duttaphrynus melanostictus* (Fig. 2A) appears to have been introduced either during the years of Indonesian occupation or with the arrival of United Nations peacekeeping troops. The species was apparently first noticed in the Oecusse District during the staging of Korean peacekeepers, and it has achieved residency throughout the lowlands of that district. It is now known

in much of Timor-Leste by its Tetun common name *Manduku INTERFET*, which connects the appearance of the toad to the deployment of peacekeepers belonging to the International Force for East Timor (acronym: INTERFET). It should be noted that our observations are consistent with those of Trainor (2009) in that the toad occurring in Timor-Leste is not the cane toad (*Rhinella marina*), which was reported in the media in 2008 and led to some consternation among Australians.

According to a short survey in September 2009 (Trainor 2009), toads are now found in most districts of Timor-Leste. The species appears to be on a relentless march across the country and its distribution now nearly extends to Lautém District (Trainor 2009). Tadpoles or hatchlings of this species have been encountered near human settlements on the southern coast of Viqueque District, and in buffalo wallows along the main coast road in the north (Fig. 3F). It appears likely that the toads will colonize the entire island in the near future.

B. Genus *Fejervarya* (Dicroglossidae)

Rice paddy frogs (genus *Fejervarya*; Fig. 4) are commonly associated with commercial and subsistence agriculture in most of continental South and Southeast Asia as well as throughout the Malay Archipelago, Wallacea, and into New Guinea (Menzies 1987, 2006). Historical reports of rice paddy frogs for the area of Timor-Leste invariably included *F. cancrivora* and *F. limnocharis*, which have been the default names applied to a relatively larger and a smaller species, respectively (Frost 2010). As research on these two taxa has allowed a better definition of their distribution (e.g., Sumida *et al.* 1998), it has become clear that neither taxon occurs on Timor, or in Timor-Leste. The only other name that could be applied to populations of *Fejervarya* in Timor-Leste is *F. verruculosa*, a species originally described by Roux (1911) from Wetar. This name was applied to Timor specimens by van Kampen (1923), Smith (1927), and Menzies (1987). Based on observations in all 13 districts of Timor-Leste, there is reason to believe that at least three species of *Fejervarya* occur in Timor-Leste, and that *F. verruculosa* is not amongst them (Kaiser *et al.* 2011). Distinction of these species by size is facilitated by the presence of three distinct size classes in mature males, which possess a pigmented throat. These observations are consistent with the vocalizations reported by Menzies (1987), although he thought that two call types were emitted by a single species. The local distribution of Timorese *Fejervarya* is complex; rice paddy frogs were observed in areas ecologically distinct from rice paddy fields, and it appears that two species frequently occur together. This likely indicates that there is one widespread generalist species that is accompanied by a different species in the lowlands and by still another one in areas at elevations >500 m. All populations of *Fejervarya* inhabit areas influenced by human habitation, e.g., agricultural plots such as rice paddies (Figs. 3C, 3D). Since only *F. cancrivora* has been reported from New Guinea, and then only from the northern portion of Irian Jaya (Menzies 2006), the populations of *Fejervarya* on Timor represent the southeastern known limit of the range of this genus.

C. *Limnonectes timorensis* (Dicroglossidae)

Smith (1927) described this endemic species (Fig. 2B) based on eight specimens he collected at Djamplong (now Tjamplong) in West Timor in wooded habitat at an elevation of 100–200 m. To date Timor river frogs were encountered only once during the present survey — in a nearly dry riverbed surrounded by coffee forest at 1,200 m elevation (Fig. 3E, 3G). Based on these disparate localities, the species appears to have a broad elevational tolerance, which translates to considerable thermal tolerance. Two specimens were encountered near the edge of the riverbed, one sitting on a large boulder and the other perched on a thin branch. No vocalizations were heard.

In his initial description, Smith (1927) placed the species into the then nearly cosmopolitan genus *Rana*. A quarter century later, Forcart (1953) synonymized *R. timorensis* with *R. elberti*, a species described by Roux (1911) from Wetar to the northeast. This synonymy was based on comparisons of preserved specimens from Sumba and East Timor in the Basel collection with the holotype of *elberti* by Robert Mertens (Forcart 1953), but without direct comparison to the holotype of *timorensis*; this synonymy was accepted by Menzies (1987). Subsequently, Dubois (1987) placed *R. timorensis* into the genus *Limnonectes*, whereas Che *et al.* (2007) placed *R. elberti* into the widespread Afro-Asian genus *Hylarana*. The present authors are using a detailed morphological analysis to further resolve the conundrum existing between *elberti* and *timorensis*.

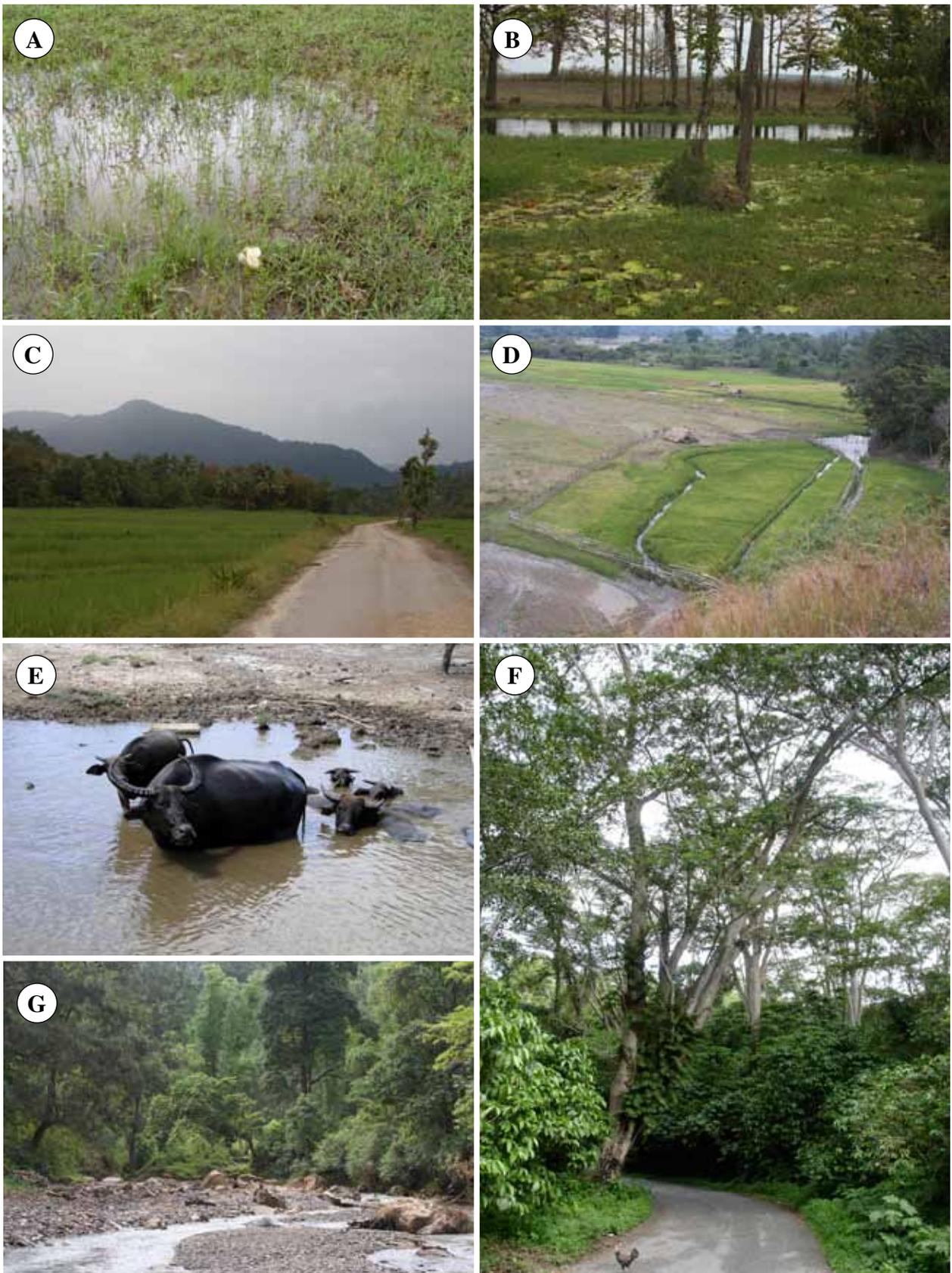


Fig. 2. Habitats of frogs in Timor Leste. (A–B) *Polypedates* habitats in Timor-Leste: **A.** Inundated high-altitude meadow near Eraulo, Ermera District. Note the foam nest in the lower portion of the photograph. Photograph by Hinrich Kaiser. **B.** Habitat along the edge of Lake Ira Lalaro, Lautém District, Timor-Leste. Photograph by Mark O’Shea. (C–D) Typical habitat of rice paddy frogs, genus *Fejervarya*, in Timor-Leste: **C.** Field north of Viqueque, Viqueque District and **D.** field at the confluence of the Tono and Abanat rivers near Pante Macassar, Oecusse District. Photographs by Mark O’Shea. **E.** Wallow along the north coast road in Manatuto District, Timor-Leste, shared by several carabao (*Bubalus bubalis*) and several size classes of Asian toad tadpoles. Photograph by Hinrich Kaiser. **F.** Coffee forest on the road between Gleno and Ermera, Ermera District, Timor-Leste. Photograph by Hinrich Kaiser. **G.** Habitat for *Limnonectes timorensis* and *Litoria everetti* at high elevation (1200 m) along the Meleotegi River near Eraulo, Ermera District, Timor-Leste. Photograph by Mark O’Shea.

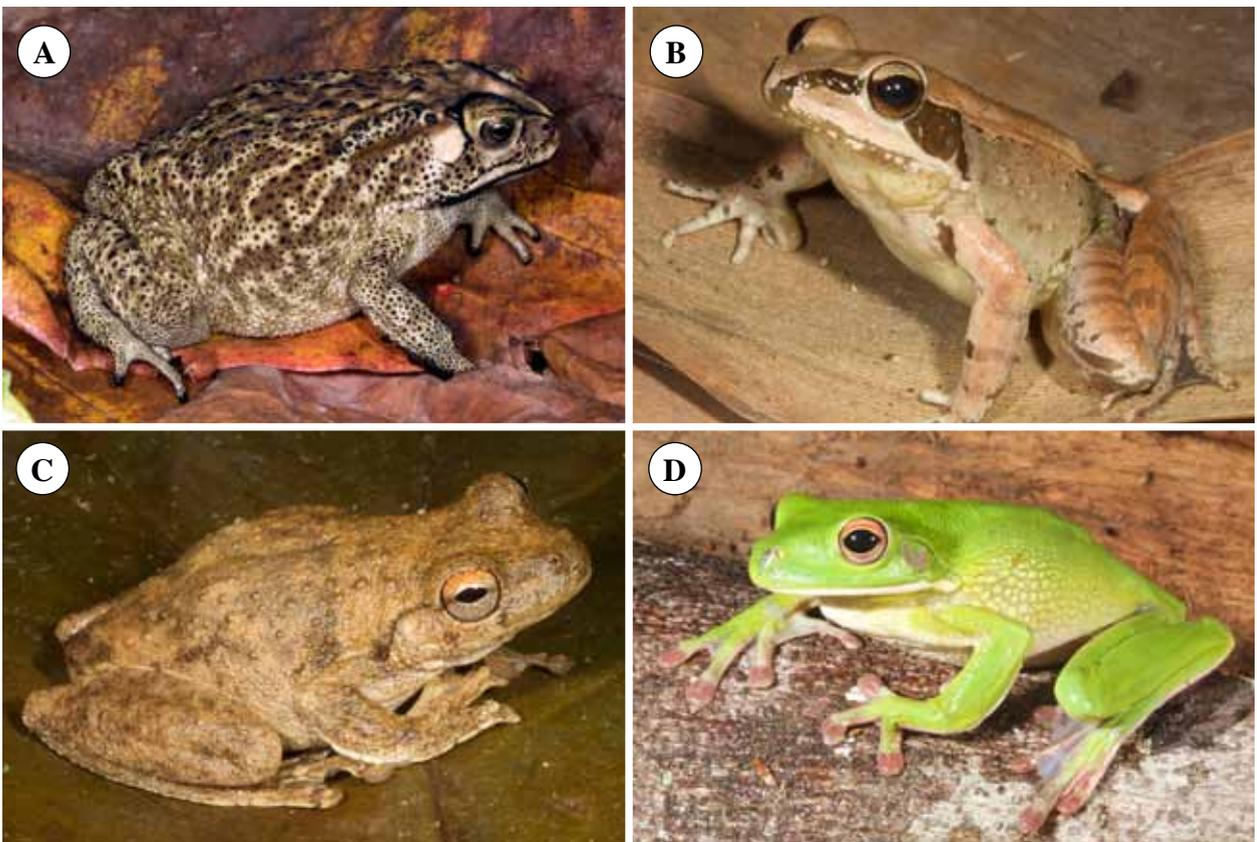


Fig. 3. Representative amphibians from Timor-Leste. **A.** A female specimen of the introduced Asian toad (*Duttaphrynus melanostictus*) from Pante Macassar, Oecusse District, Timor-Leste. Presence of black pigmentation on the cranial crests and the elongate parotid gland differentiate this species clearly from the cane toad *Rhinella marina*. Photograph by Mark O'Shea. **B.** Female *Limnodynastes timorensis* from near Eraulo, Ermera District, Timor-Leste. Photograph by Mark O'Shea. **C.** Female *Litoria everetti* from near Eraulo, Ermera District, Timor-Leste. Photograph by Mark O'Shea. **D.** *Litoria infrafrenata* from Papua New Guinea. The authors have not personally recorded this species from Timor-Leste. Photograph by Mark O'Shea.

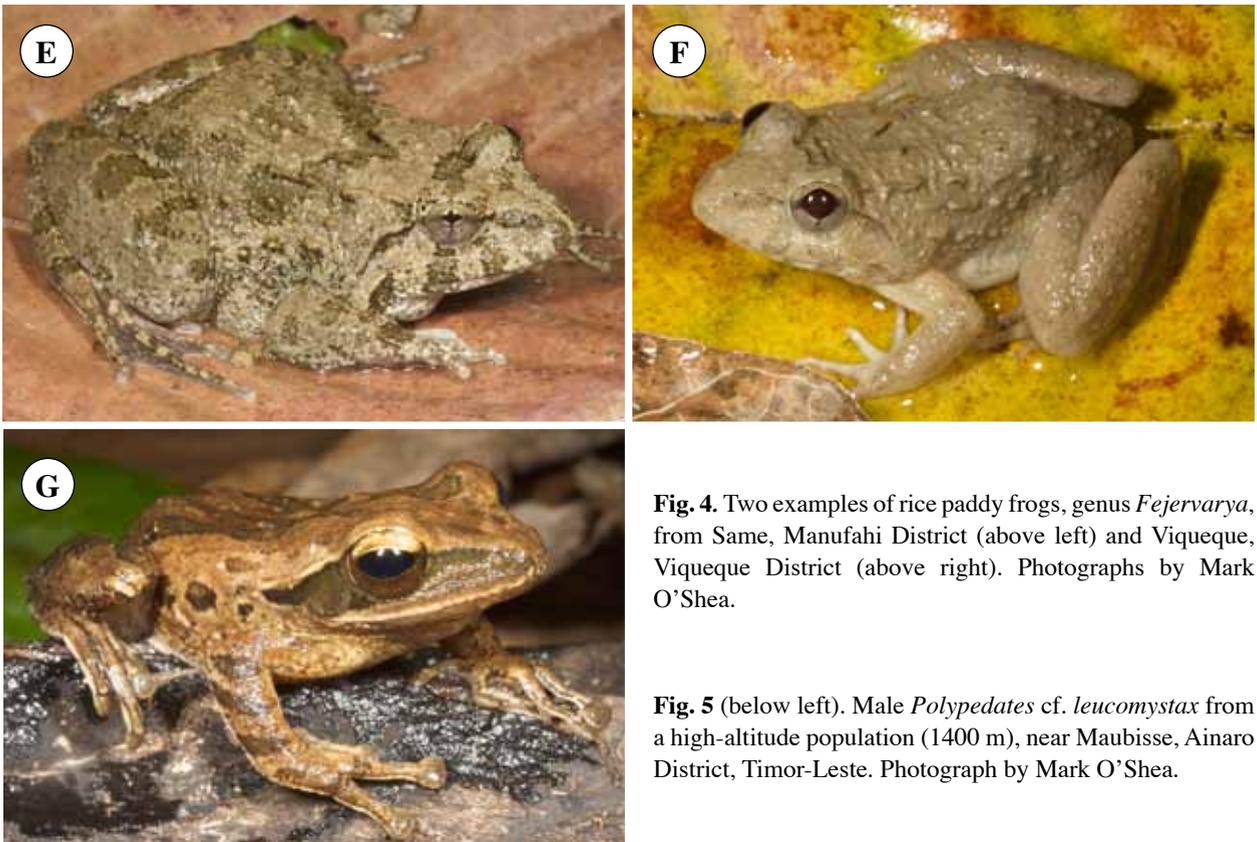


Fig. 4. Two examples of rice paddy frogs, genus *Fejervarya*, from Same, Manufahi District (above left) and Viqueque, Viqueque District (above right). Photographs by Mark O'Shea.

Fig. 5 (below left). Male *Polypedates* cf. *leucomystax* from a high-altitude population (1400 m), near Maubisse, Ainaro District, Timor-Leste. Photograph by Mark O'Shea.

Based on its inclusion in the genus *Limnonectes*, the species is a component of the Southeast Asian biota. Only a single species of *Limnonectes* (*L. grunniens*) extends the generic range eastward beyond Lydekker's Line and into New Guinea. The population of *L. timorensis* on Timor therefore exists at the southeasternmost extreme of the range of the genus.

D. *Litoria everetti* (Hylidae)

This treefrog (Fig. 2C) was originally described by Boulenger (1897) based on the collections made by the natural historian, Alfred Everett on Sumba and Savu in the 1890s. The connection with Timor was first made by van Kampen (1907, 1923), but without examining specimens. Smith (1927) collected several individuals and tadpoles in puddles near Tjamplong (elevation 100–200 m) and Soë (elevation 800 m) in West Timor. In the present project, *L. everetti* was encountered on the same night and in the same locality as *Limnonectes timorensis* (Fig. 3G) at an elevation of 1,200 m. Menzies (2006) reported the species from the Lesser Sunda Islands in general, specifically naming Alor, Savu, Sumba, and Timor, with a distribution ranging in elevation from sea level to 1500 m.

E. *Litoria infrafronata* (Hylidae)

Litoria infrafronata (Fig. 2D) was first reported from Timor by Bleeker (1860) using the species name *Hyla cyanea* Daudin 1803, a taxon now in the synonymy of *Litoria caerulea*. At the time of Bleeker's report, the name *cyanea* was the only one available for a bright green treefrog from the far reaches of the Dutch East India Company's sphere of influence. Seven years after Bleeker's report, Günther (1867) and Cope (1867) described new green treefrogs as *Hyla infrafronata* and *Calamita dolichopsis*, respectively. Whereas Günther's specimens came from Australia, those of Cope were collected in the Moluccas. Thus, there was confusion in the nomenclature of this species, expressed by the use of both names by Boulenger (1882). The confusion began to settle after van Kampen (1907) used the name *dolichopsis* with a superscript to indicate synonymy with *infrafronata*, but several years later Cope's name was still in use (Barbour 1912). The name *infrafronata* was standardized in relation to Wallacean populations by the list of van Kampen (1923). During this time, Bleeker's (1860) specimen remained the only one from Timor. This species has not been encountered during the present surveys.

F. Genus *Polypedates* (Rhacophoridae)

Among the most commonly encountered frogs in Timor-Leste are treefrogs of the genus *Polypedates* (Fig. 5). These treefrogs have been found in habitats ranging from coastal swamp forests to riverbeds and meadows at an elevation of over 1400 m (Fig. 3A), including seasonally inundated habitats along the edge of Lake Ira Lalaro, Timor-Leste's largest freshwater body (Fig. 3B).

Hitherto, the nomenclatural assignment given to the majority of populations of *Polypedates* throughout Wallacea and many parts of the Sunda Shelf is *leucomystax*, although recent molecular work (Brown *et al.* 2010) has revealed considerable taxonomic and biogeographic complexity in this taxon and has demonstrated the need for additional research. As a consequence, it is impossible to say, as of this writing, whether rhacophorid frogs on Timor are part of the widespread species *P. leucomystax*, whether they should be recognized by another available name, or whether they constitute an unnamed species.

Present research has allowed us to recognize two possibly distinct types of *Polypedates* in Timor-Leste. One of these is a rhacophorid of variable phenotype with sexual size dimorphism of <1.2 in the ratio of females' to males' snout — vent length. The second type has considerably greater sexual dimorphism (>1.5), with all collected females possessing several parallel stripes on the dorsum. An expanded investigation of rhacophorid populations in Wallacea is currently being conducted by Rafe Brown and coauthors (personal communication).

III. CONSERVATIONAL CHALLENGES

Timor-Leste (area 14,874 km²) is a small island nation, yet it has been the site of considerably more historic strife than its area's share of the world's stage. It is this history and the negligent foreign powers that contributed to it,

combined with a resulting lack of development and education, that set the stage for the conservational challenges faced today by its environment and, by extension, its amphibians.

A. Colonialism and Environmental Degradation

Even before the Portuguese started a series of attempts to establish an outpost on Timor in the first half of the 16th century, Chinese and Javanese traders had been conducting an unsustainable trade in sandalwood (*Santalum album*), honey, and wax, dating back to the mid-14th century (McWilliam 2005). Power plays by local rulers, persistent pressure from the Portuguese, and the establishment of the Dutch East India Company as an economic powerhouse throughout the region resulted in significant environmental impacts, initially to coastal forests along the northern shores of Timor, but over time reaching further and further inland. Even though sandalwood was by far the most highly valued commodity of the time, other natural resources began to feel the pressure of supplying trading posts with materiel and food as the Dutch and Portuguese relentlessly pursued their economic goals. As the sandalwood supply dwindled, even in the more inaccessible regions of the island (McWilliam 2005), both Dutch and Portuguese administrations introduced coffee as the new cash crop (Fox 2003). This dramatically changed the ecology of the new coffee-growing regions, introducing the ‘coffee forest ecosystem’. This ecosystem has been a mixed blessing for local biodiversity. Even though coffee plantations may take on the appearance of lush forested tracts of land (Fig. 3E), their diversity is more limited (e.g., Senbeta and Denich 2006) and organisms lacking considerable physiological plasticity may not be able to live in the shade of *Coffea arabica*.

B. Subsistence Farming and Environmental Degradation

While the plunder of the more desirable crops by colonial powers continued, the local population was forced to seek alternative means of filling their own needs. The Dutch East India Company sought to alleviate this problem while adding a suitable food for its own personnel by introducing maize in the Kupang area of West Timor (Fox 2003). This new crop was accepted rapidly by the population and quickly spread into the Portuguese areas of the island. Even though maize is grown readily in most tropical soils, it generally requires the clearing of other vegetation that, on the steep and exposed terrain of Timor Island, invariably leads to erosion (Fig. 6).

With the increasing scarcity of tracts of woodland in close proximity to human habitations, the acquisition of firewood proved a costly secondary source of forest degradation. Instead of foreign exploitation of accessible trees, some of the more remote locations were becoming targeted for cutting of trees for firewood. This situation was exacerbated during the time of the Indonesian occupation, when a lack of infrastructure for over half of the territory’s population and the deployment of a resistance army throughout its most remote regions for more than two decades, caused significant deforestation. The social cost of obtaining firewood from the forest is also considerable, as young children tend to collect firewood instead of attending school (Fig. 7).



Fig. 6. Hillside erosion along the road from Dili to Gleno, Dili District, Timor-Leste. This particular instance of erosion occurred after clearing of vegetation, but weeks of heavy rain had prevented the planting of maize. Photograph by Hinrich Kaiser.

It is clear that habitat fragmentation as part of subsistence farming or the establishment of plantations may result in limiting population sizes to the point where they may not be genetically self-sustaining. Even though clear-zoning of habitats as part of rural development probably has not happened in East Timor, it is a looming danger as the country embarks on the path to greater prosperity.

C. Inadequate Taxonomy

Only since 1999, and after a 20-year conflict-induced hiatus, has East Timor again been open to biological fieldwork. As a consequence, research on the amphibian fauna, using modern techniques and comparative approaches, is now resuming. While some of the morphological work of past authors (e.g., Smith 1927, Forcart 1953, Menzies 1987) is commendable, discoveries of additional species and a better understanding of the biogeography of Wallacea requires work that includes the frogs of East Timor. For example, the taxonomy of rhacophorid frogs is uncertain at the moment. Among the more established species (e.g., *Limnonectes timorensis*, *Litoria everetti*), care should be taken to ensure that specimens from lowland and highland localities, or in the case of *L. everetti* from different islands, truly conform to the nominate form. Elevational differences or island allopatry are well known forces that create different selective pressures. Clearly, the taxonomy of rice paddy frogs (*Fejervarya*) is in dire need of resolution.



Fig. 7. A young boy walking home after collecting firewood in Gleno, Ermera District, Timor-Leste. Photograph by Hinrich Kaiser.

D. Introduced Species

The normal invasive culprits enacting habitat destruction include domesticated livestock and feral pets. Undoubtedly, in the areas around human habitations, there is greater potential for predation by dogs than there is in more remote localities. The movement of buffalos across meadows increases the possibility that a foam nest is destroyed or that a seepage area becomes contaminated by feces. A greater threat, however, emanates from the introduced *Duttaphrynus melanostictus* (see Trainor 2009). This species is capable of occupying niches in which other species (both frogs and smaller reptiles) exist, is a formidable predator of small frogs and small reptiles (e.g., geckos, skinks), and it can become a nuisance and an object of pursuit in human habitations, to the extent that frogs may be considered equally offensive as toads merely by having a similar appearance.

E. Nation-Building Issues

Even though the political leadership of Timor-Leste, notably President Jose Ramos-Horta and Prime Minister Xanana Gusmão, is solidly committed to creating an economy in line with principles of sustainability and environmental stewardship, there are institutional issues that the young country inherited from its past, which still need to be addressed. For example, the government's unit in charge of the environment resides within the Ministry for Economics and Development, whereas the National Directorate of Forests (including the Directorate of National Parks) resides in the Ministry of Agriculture and Fisheries. Thus, when it comes to environmental issues two large bureaucracies are involved instead of a single department. Furthermore, in the eight years since independence, there have been several waves of civil unrest, each of which curbed the ability of institutions of higher learning to be built or modernized. Thus, the drive to build capacity for research conducted by locals, and to train administrators in the understanding of natural processes (e.g., food webs, nutrient cycles) and their impact on the population is only now beginning.

IV. OUTLOOK FOR CONSERVATION

A reading of the five preceding challenges lends credence to the idea that, from an environmental standpoint, Timor-Leste is a troubled land and that conservational activities are sorely needed. However, During research over the past two years, however, a burgeoning groundswell of activity has been encountered that is truly homegrown and not limited to imported NGOs. Visible successes include the establishment of Konis Santana National Park, the designation of nearly 30 protected areas of special conservation concern, the staffing of key positions in the bureaucracy with knowledgeable and competent personnel, sometimes supported by international advisors, and the existence of strongly committed political leaders. One begins to see an increased awareness of natural treasures (the country's newest postage stamps feature photographs of amphibians and reptiles) and of conservation issues, which are promoted by some of the students from the Universidade Nacional Timor-Lorosa'e, the country's main institution of higher learning. The country's president is considering the establishment of a nature reserve along with an education-centred botanical and zoological garden. Some of the plans proposed by the present authors have received governmental approval and include a toad-awareness campaign, the preparation of a children's book in ten main local languages, and an increased focus on field research as part of both the university's academic program in biological sciences and the training in government agencies.

While it is certainly true that the amphibians of Timor-Leste have experienced some of the worst environmental degradation possible, what remains appears to be a complete sample of what was originally present. As educational and management policies take hold, it is likely that this country's frogs will match the resilience shown by its people. Even though the country's history has placed Timor-Leste and its amphibians in an environmentally unenviable position, there is determination to see improvements and, unlike the situation in many developing countries, there is apparently no opposition to these efforts.

V. ACKNOWLEDGMENTS

Our research in Timor-Leste has benefited greatly from the active support of political leaders, including Prime Minister Xanana Gusmão, President Jose Ramos-Horta, and President of Parliament Lasama de Araujo. Their genuine desire to develop Timor-Leste based on principles of sustainability and sound environmental policy is a silver lining on the receding darkness. For this continuing support, we are very grateful. None of the relationships we have been able to develop in the country would have been possible without the interest and intercession of Claudia Abate, Senior Advisor to the Prime Minister, who has become a *de facto* member of our team. In many instances, we were able to rely on the patient and effective assistance of Ágio Pereira, Secretary of State for the Council of Ministers, and his Executive Assistant Sonia Lobato Leitão, who were able to fix almost anything, and at the last minute. Fieldwork was carried out with the help of students enrolled in three courses at Victor Valley College, including Paul Freed, Barbara Lester, Margaret Andrews, Annie Suzio-Granett, Dan Suzio, Venancio Lopes Carvalho, Laca Agivedo Ribeiro, Zito Afranio, Luis Lemos, Andrew Kathriner, Christy Le Duc, Caitlin Sanchez, Jester Ceballos, Scott Heacox, Eric Leatham, Mariana Tucci, Mary Jane Weil, and Dominique Fallas. We are especially thankful to Manuel Mendes, Director of National Parks, for the opportunity to conduct research in Konis Santana National Park and for issuing research and export permits. Preparation of these research courses was supported by stipends to HK from a Title V Grant to Victor Valley College. Student travel was supported by travel grants from the Associate Student Body at Victor Valley College to several of our U.S.-based students. This chapter is Contribution No. 5 from the Tropical Research Initiative at Victor Valley College.

VI. REFERENCES

- Barbour, T., 1912. A contribution to the zoögeography of the East Indian Islands. *Memoirs of the Museum of Comparative Zoölogy* **44**: 1–203.
- Bleeker, P., 1860. Reptiliën van het eiland Timor. In: Bestuursvergadering, gehouden den 12th April 1860, ten huize van den Heer G.F. de Bruyn Kops. *Natuurkundig Tijdschrift voor Nederlandsch-Indië* **20**: 86–88.

- Boulenger, G.A., 1882. "Catalogue of the Batrachia Salientia S. Ecaudata in the Collection of the British Museum". Second Edition. Trustees of the British Museum of Natural History, London, United Kingdom.
- Boulenger, G.A., 1897. A list of the reptiles and batrachians collected by Mr Alfred Everett in Lombok, Flores, Sumba, and Savu, with descriptions of new species. *Annals and Magazine of Natural History, 6th Series* **19**: 503–509.
- Bowin, C., Purdy, G.M., Johnston, C., Shor, G., Lawver, L., Hartono, H.M.S., Jezek, P., 1980. Arc-continent collision in the Banda Sea region. *Bulletin of the American Association of Petroleum Geologists* **64**: 868–915.
- Breen, N.A., Silver, E.A., Roof, S., 1989. The Wetar Back Arc Thrust, Eastern Indonesia: the effect of accretion against an irregularly shaped arc. *Tectonics* **8**: 85–98.
- Brown, R.M., Linkem, C.W., Siler, C.D., Sukumaran, J., Esselstyn, J.A., Diesmos, A.C., Iskandar, D.T., Bickford, D., Evans, B.J., McGuire, J.A., Grismer, L., Supriatna, J., and Andayani, N., 2010. Phylogeography and historical demography of *Polypedates leucomystax* in the islands of Indonesia and the Philippines: Evidence for recent human-mediated range expansion? *Molecular Phylogenetics and Evolution* **57**: 598–619.
- Chappell, J., Veeh, H.H., 1978. Late Quaternary tectonic movements and sea level changes at Timor and Ataúro Island. *Bulletin of the Geological Society of America* **89**: 356–368.
- Che, J., Pang, J., Zhao, H., Wu, G., Zhao, E., and Zhang, Y., 2007. Phylogeny of Raninae (Anura: Ranidae) inferred from mitochondrial and nuclear sequences. *Molecular Phylogenetics and Evolution* **43**: 1–13.
- Cope, E.D., 1867. On the families of the raniform Anura. *Journal of the Academy of Natural Sciences of Philadelphia, Series 2*, **6**: 189–206.
- Dubois, A., 1987. Miscellanea taxinomica batrachologica. I. *Alytes* **5**: 7–95.
- Forcart, L., 1953. Die Amphibien und Reptilien von Sumba, ihre zoogeographischen Beziehungen und Revision der Unterarten von *Typhlops polygrammicus*. *Verhandlungen der Naturforschenden Gesellschaft Basel* **64**: 356–388
- Fox, J.J., 2003. Tracing the path, recounting the past: historical perspectives on Timor. Pp. 1–27 in "Out of the Ashes: Destruction and Reconstruction in East Timor", ed. by J.J. Fox and D.B. Soares. Australian National University Press, Canberra, Australia.
- Frost, D.R., 2010. Amphibian Species of the World: an Online Reference. Version 5.4 (8 April 2010). Electronic Database accessible at <http://research.amnh.org/vz/herpetology/amphibia>. American Museum of Natural History, New York, USA.
- Günther, A.C.L.G., 1867. Additions to the knowledge of Australian reptiles and fishes. *Annals and Magazine of Natural History, Series 3*, **20**: 45–68.
- Kaiser, H., Lopez Carvalho, V., Ceballos, J., Freed, P., Heacox, S., Lester, B., Richards, S.J., Trainor, C.R., Sanchez, C., O'Shea, M., 2011. The herpetofauna of Timor-Leste: a first report. *Zookeys*: in press.
- Keep, M., Longley, I., Jones, R., 2003. Sumba and its effect on Australia's northwestern margin. *Geological Society of Australia Special Publication* **22**: 309–318.
- McWilliam, A., 2005. Haumeni, not many: renewed plunder and mismanagement in the Timorese sandalwood industry. *Modern Asian Studies* **39**: 285–320.
- Menzies, J.I., 1987. A taxonomic revision of Papuan *Rana* (Amphibia: Ranidae). *Australian Journal of Zoology* **35**: 373–418.
- Menzies, J.I., 2006. "The Frogs of New Guinea and the Solomon Islands". Pensoft Publishers, Sofia, Bulgaria.
- Roux, J., 1911. Elbert-Sunda-Expedition des Frankfurter Vereins für Geographie und Statistik. Reptilien und Amphibien. *Zoologische Jahrbücher, Abteilung für Systematik, Geographie und Biologie der Tiere* **30**: 409–508.
- Senbeta, F. and Denich, M., 2006. Effects of wild coffee management on species diversity in the Afromontane rainforests of Ethiopia. *Forest Ecology and Management* **232**: 68–74.
- Smith, M., 1927. Contributions to the herpetology of the Indo-Australian Region. *Proceedings of the Zoological Society of London* **97**: 199–226.
- Sumida, M., Allison, A., and Nishioka, M., 1998. Genetic relationships and phylogeny of Papua New Guinean hyloid frogs elucidated by allozyme analysis. *Japanese Journal of Herpetology* **17**: 164–174.
- Trainor, C.R., 2009. Survey of a population of black-spined toad *Bufo melanostictus* in Timor-Leste: confirming identity, distribution, abundance and impacts of an invasive and toxic toad. Report by Charles Darwin University to AusAID, contract agreement no. 52294.
- van Kampen, P.N., 1907. Amphibien des Indischen Archipels. Pp. 383–418 in "Zoologische Ergebnisse einer Reise in Niederländisch Ost-Indien", Volume 4(2), ed. by M. Weber. E.J. Brill, Leiden, The Netherlands.
- van Kampen, P.N., 1923. "The Amphibia of the Indo-Australian Archipelago". E.J. Brill, Leiden, The Netherlands.