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Dedicated to the memory of Julian S. Kenny

Glasgow's Trinidad and Tobago Biodiversity Connection

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ABSTRACT
The University of Glasgow's biodiversity connection with Trinidad and Tobago began with Roger Downie's research visit in 1982 to work on amphibians under the guidance of Julian Kenny. This paper reviews the fruits of this connection over nearly 30 years and is dedicated to Julian Kenny's memory. Much of Glasgow's work in Trinidad and Tobago has involved teams of staff and students spending two to three months of a year in the Caribbean on "expeditions" studying aspects of biodiversity. Amphibians and marine turtles have been the main focus, but many other groups have been studied too. Major outputs have been four Ph.D. theses and well over 70 research papers in international journals.

Key words: Trinidad, Tobago, biodiversity, student-staff expeditions, Glasgow University, golden tree frog, *Mannophryne trinitatis*, marine turtles.

INTRODUCTION

When I was considering a new research direction into amphibian reproductive ecology back in 1980, I wrote to an ex-student, Robin Bruce, then on a three-year contract in the Zoology Department, University of the West Indies, St. Augustine, Trinidad, and asked him: are there any interesting frogs in Trinidad? His reply was immediate (or as immediate as replies were in those pre-email days): yes, Trinidad has many interesting frogs. Furthermore, his head of department, Julian Kenny, had written a full account of these frogs and their natural history, including a key to the tadpoles (Kenny 1969, 1977). We soon established that Professor Kenny welcomed visitors, especially those interested in amphibians, so in April 1982 my family and I arrived in Trinidad, our first ever visit to a tropical country, to spend five months research leave. In those days, choked drainage ditches and undeveloped areas of ground in St. Augustine supported a wide range of amphibian species (sadly, for frog hunters, no longer the case), and I was able to learn a lot by simply walking around the campus. But for the less accessible species, it was necessary to get into the countryside. It was then that Julian Kenny (universally known as Jake) and his excellent field technician, Pouran, became our indispensable guides, taking us on night excursions to Valencia and Icacos, where they could unerringly detect most frogs by their calls.

That visit generated enough interesting observations that I was able to write my first Trinidad-based frog research paper (Downie 1984) and to justify two further short research visits in 1983 and 1987 (producing further publications: Downie 1988, 1989). It was clear that there was scope for much more work. Around that time, a group of colleagues at the University of Glasgow decided that it would be beneficial to revive the University's Exploration Society. This had existed, sporadically, since the 1920's, but was in a fallow phase. The Society was re-constituted with the full (and crucial) support of the Principal, Sir Alwyn Williams, a field palaeontologist. One of the first expeditions sponsored by the new Society took place in 1989, the first undergraduate expedition to Trinidad and Tobago from the University of Glasgow. The idea of an expedition to Trinidad and Tobago derived not only from our earlier work but also from the arrival in Glasgow of Richard Rutnagur, a Ph.D. student with Trinidadian family: he acted as expedition leader. This began the connection that has persisted and been highly productive till the present day. This short paper summarises the range of work done by these expeditions, all the fruit of that early connection with Julian Kenny, and therefore dedicated to his memory following his untimely death in August 2011.

THE EXPEDITIONS

In the 23 years covering 1989 to 2011, the University of Glasgow Exploration Society has organised 17 expeditions to Trinidad. The first two (1989, 1991) included project teams in Tobago as well as in Trinidad. In 2004, a new annual expedition series began on Tobago to work on marine turtles with the recently formed NGO Save Our Sea-Turtles (SOS) Tobago: there have been eight such expeditions so far.

Trinidad expeditions have generally lasted eight weeks and been based at St. Augustine (making use of UWI laboratory facilities) or at the William Beebe Field Station (Simla) in the Arima Valley. Project teams have

often spent substantial time away from base e.g. at Matelot, when working on north coast turtle beaches, or at Trinity Hills when working on bats. Tobago turtle expeditions have lasted 6-10 weeks and have been based at Black Rock.

Trinidad expeditions have in total brought 347 participants to the island (mean: 20.4 per expedition), 72% undergraduates, 8% postgraduate students and 20% staff (a few staff have participated multiple times; a few expedition members have taken part successively as undergraduate, postgraduate and staff). There have also been many short-term visitors. Tobago expeditions have so far involved 82 students (mean: 10.3 per expedition). These have been almost entirely undergraduates, with a few associated Masters students undertaking research projects and staff making occasional short supervisory visits.

On average, Trinidad expeditions have cost £1,120 per participant: over the 17 expeditions, that amounts to a total of about £400,000 ($4 million TT). In the early expeditions when we always flew BWIA, effectively all this money was spent in Trinidad on a mix of air fares, accommodation, car hire and fuel costs, food and locally purchased equipment. Tobago expeditions have cost £1,750 per participant. The cost of living (accommodation, food) is higher in Tobago than in Trinidad, and Tobago expeditions have mostly lasted longer, but Tobago expeditions have generally not needed to hire vehicles or to purchase much equipment.

Trinidad expedition costs have been met by a combination of participant personal contributions (on average 51% of total cost i.e. £570 or $5,700 TT) and fund-raising efforts. Most funds derive from grant applications to a range of sympathetic UK-based charitable trusts including the Carnegie Trust for the Universities of Scotland – which has funded every Trinidad expedition to date. In addition, students organise a range of fund-raising events such as bake sales, quizzes, sponsored swims etc. (the fund-raising pattern for Tobago expeditions has been very similar). Very importantly, the University of Glasgow provides some financial support for all expeditions that pass an approval process, and this has applied to all Trinidad and Tobago expeditions. University approval is a pre-requisite for funding from some charitable trusts.

The main work of the new series of Tobago expeditions since 2004 has been to contribute to the basic marine turtle monitoring undertaken by SOS Tobago at three 'index' beaches: Turtle Beach, Grafton and Back Bay. In addition, Glasgow students have helped with tourist education and have allowed SOS Tobago to extend their monitoring to the many small remoter beaches around the island. This has turned out to be important, especially for estimating the numbers of nesting hawksbills, which mainly use these smaller beaches. Glasgow students have also undertaken a small number of specific research projects: for example, on tourist attitudes to marine turtles, and on the environmental factors that influence nesting patterns.

PROJECT WORK IN TRINIDAD AND TOBAGO

Overview

Each Trinidad expedition has normally included several distinct projects with staff and students working in flexible teams. An approximate breakdown of project themes is shown in Table 1. Work on amphibians has been the predominant theme and has occurred on every expedition. This has included studies on embryonic and larval adaptations, the ecology of reproductive modes, the mechanism of adhesion in tree frogs, the phylogenetics of Trinidad's frogs, species distributions, and the population dynamics and conservation needs of threatened species.

Table 1. Distribution of Trinidad (and Tobago 1989, 1991) project topics (%); n = 111.

Proportion	Project Topics
46	Amphibians: reproductive ecology; basic biology; conservation
23	Invertebrates: crabs; insects; corals; parasites; molluscs
11	Birds: diversity; population dynamics; conservation
9	Reptiles: marine turtle nest monitoring; snake and lizard ecology
5	Mammals: bats; monkeys; wild pigs
5	Education: summer camps; primary schools
1	Fish: one study on Nariva Swamp
1	Forest: one study on Tobago

Work on invertebrates has been the next biggest theme. This has been very varied: land crab behaviour, the fauna of bromeliad tanks, the occurrence of saproxylic insects, the species of fossil corals in Trinidad and the health of Tobago's living coral reefs, reproduction in the invasive freshwater snail *Melanoides*, the significance of wing asymmetry in the mantis *Tithrone roseipennis*, the distribution and effects of parasites in toads, goats and people.

Half of our expeditions have included one or two projects on birds. This has included making population estimates of the endangered pawi; investigating how oropendolas make their nests; studying the effectiveness of captive breeding in tree-ducks; studying whether black

vultures contribute to the spread of disease; and assessing the diversity, movement and longevity of Northern Range forest birds.

About half of our expeditions have worked on reptiles. Most of this has been on marine turtles on the north and east coasts of Trinidad, where we have monitored nesting numbers (mainly of leatherbacks) and assessed nesting success and threats to the population.

Six expeditions have included projects on mammals: three estimated monkey populations and recorded their behaviour in Nariva Swamp; two estimated bat populations and species diversity in south Trinidad; and one attempted the release of captive-bred wild pigs in central forests.

Education has been another recurring theme. We have been invited to take part in biodiversity education on summer camps and in schools. In 2010 (and planned to continue to 2014), the British Council funded a schools link between Trinidad and Glasgow with biodiversity as one of its main themes. We have contributed to the initial work of this theme both in Glasgow and Trinidad, and hope to continue in the future.

A general lack in our expeditions has been work on plants, reflecting the low level of botanical staffing at Glasgow University. Our first expedition included a study of post-hurricane forest regeneration in Tobago: we have done no serious work on plants since, though occasional projects have enlisted the assistance of UWI botanists to help identify plant species.

Achievements

Table 1 illustrates the diversity of our work in Trinidad and Tobago, and it would not be possible to make a coherent summary of all our achievements. Instead, I'll pick out a few themes.

The golden tree frog is one of Trinidad's most iconic species, having appeared on stamps and occurring in the world only on El Tucuche and El Cerro del Aripo. It is assessed as Critically Endangered on IUCN's Red List, the only Trinidad amphibian species with this status. There are remarkably few published studies of this species and two of them result from our expeditions. Clarke *et al*. (1995) estimated the golden tree frog population of El Tucuche as 20,000 and discussed reasons for its strong habitat choice in the water reservoirs of the giant bromeliad *Glomeropitcairnia erectiflora.* Later, Jowers *et al*. (2008) used molecular taxonomy methods to demonstrate the golden tree frog's uniqueness. It has long been classed in the small hylid genus *Phyllodytes*. However, Jowers *et al*. showed that it is not closely related to other *Phyllodytes* and that it should be placed in a genus of its own: its new name is *Phytotriades auratus*.

The Trinidadian stream frog *Mannophryne trinitatis* was considered to occur both in Trinidad and on the Paria Peninsula of Venezuela. However, work by Michael Jowers (Manzanilla *et al*. 2007) on our expeditions showed that the Paria Peninsula population is a distinct species, making *M. trinitatis* a Trinidad endemic. We have published several studies on the reproductive strategies and behaviour of this frog. Downie *et al*. (2001) showed that transporting males (this species guards its eggs on land and the male carries the hatchlings on its back till it finds water) are choosy in where they deposit their hatchlings, spending time to find predator-free water bodies (Figs. 1, 2). Downie *et al*. (2005) investigated the constraints in transporting males: can they carry hatchlings for sev-

Fig. 1. The Trinidadian stream frog *Mannophryne trinitatis*, a male transporting its babies (photo credit: Joanna Smith).

Fig. 2. Glasgow students capturing Trinidadian stream frogs near Maracas Waterfall (photo credit: Gillian Simpson).

Table 2. Glasgow Ph.D. theses largely based on Trinidad expedition work.

Student	Year of Completion	Thesis Title
Joanna Smith	2003	Effects of allometric growth and toe-pad morphology on adhesion in hylid tree frogs.
Mohsen Nokhbatolfoghahai	2003	Anuran embryo and larval surface structures: studies on patterns, timing and variation in the development of anuran surface ciliation, adhesive glands and hatching gland cells.
Michael Jowers	2006	Phylogeography and molecular ecology of predators and prey in Trinidad and Tobago.
Suzanne Livingstone	2006	Sea turtle ecology and conservation on the north coast of Trinidad, West Indies.

eral days without seriously endangering themselves or their hatchlings? A surprising finding was that the extra weight (a full complement of hatchlings can be 30% of a male's weight) does not significantly affect their escape response. We have produced a children's story based on an imaginative version of a stream frog's quest to find a suitable place for his tadpoles, and this has been performed as a play to schoolchildren in both Glasgow and Trinidad as part of our educational work.

Marine turtle nest monitoring was part of our very first Trinidad expedition, at the suggestion of the Wildlife Section. The findings from that work (Godley *et al*. 2001) fed into the discussions that led to the formation of Nature Seekers at Matura, as a locally-based NGO whose members would generate ecotourist income from their turtle conservation work. This model spread to other localities, notably Grand Riviere and Fishing Pond on Trinidad and later to SOS Tobago. Marine turtle work has been a focus on nine of our Trinidad expeditions and the central theme of our eight SOS Tobago-linked expeditions. Suzanne Livingstone's Darwin Initiative – funded project extended over four expeditions with a follow-up in 2010. This established the importance of the remoter north coast beaches as leatherback nesting sites (Livingstone and Downie 2005) and carried out work on threats to turtles from by-catch, nest metabolic heating and infestation of nests by insects (Fig. 3). In Tobago, we have helped establish that the smaller beaches distant from the three main beaches around Black Rock are important for turtles, especially hawksbills.

Outputs

The results of all these expeditions have led to a range of publications. First, each expedition has produced a report. Copies of all Trinidad reports are available in the UWI Library, and most are also in the Zoology Library. Tobago reports are available from SOS Tobago. In addition, Glasgow University Exploration Society has a website (http://www.martinmuir.com/glasgowexsoc) and has begun to develop an archive for all past expedition reports.

As noted earlier, expedition participants have included postgraduate students as well as undergraduates. Four of those have based most of their Ph.D. theses on work done in Trinidad (Table 2) and others have included some Trinidad work. There have also been several Masters research projects, including students from other UK universities who have visited our expeditions.

Fig. 3. Excavating hatched leatherback turtle nests on Trinidad's north coast to check for indicators of incubation success (photo credit: Suzanne Livingstone).

Fig. 4. The Dudley Huggins Laboratory, University of the West Indies, set out with a range of aquaria and other equipment for Glasgow expedition projects (photo credit: Gillian Simpson).

In addition, work done on Trinidad and Tobago expeditions has led to the publication of over 70 scientific papers in international peer-reviewed journals (see Appendix). Some may find this a surprising outcome for work largely done by undergraduate students, but if such work is well supervised, there is no reason why it should not produce competent publishable science. One of the satisfying results of our expeditions is how often they have helped young scientists to make a career start by producing their first publication: over 40 of the authors of the papers listed in the Appendix were undergraduates when they did the reported work. Rather a small number of these papers have been published in *Living World*: examples are Jowers and Downie (2004), Downie and Nicholls (2004) and Burgon *et al.* 2012. We hope more will appear in future.

Interactions

Expeditions of the sort described here do not work in a vacuum: they depend a great deal for their success on their interactions with local people and organisations. It would be a huge task to list all the people in Trinidad and Tobago who have contributed to the work we have done on expeditions (and another list for those who have helped us to taste the delights of Trinidad and Tobago culture). All those are listed and thanked in the Acknowledgements sections of each expedition report. Here, I would like to mention some of our long-term interactions.

From the beginning, we felt it was important to carry out work of value to biodiversity conservation in Trinidad and Tobago. To this end, nearly all our expeditions to Trinidad have worked closely with staff of the Wildlife Section, Forestry Division. Dr. Carol James was still in charge there when we began and through her suggestions, we carried out work on pawi, quenk and marine turtles. Our marine turtle work at Matura in 1989 paved the way for the establishment of Nature Seekers, the locally based NGO which monitors and protects the nesting beach at Matura and allows local people to benefit financially through tour-guiding. We later extended our Trinidad turtle work to the north coast, collaborating with local groups at Grand Riviere and Matelot. More recently, we have worked with the group at Fishing Pond. Other projects in collaboration with the Wildlife Section have included a study of the success of whistling duck captive breeding and release (in collaboration with the Wildfowl Trust at Pointe-à-Pierre); detailed behavioural and population studies on the white fronted capuchin and red howler monkey troops at Nariva; and comparative studies of bat populations in primary and secondary forest in the Trinity Hills area.

Another important Trinidad interaction has been with the University of the West Indies. The zoologists there have provided us with a large laboratory (Fig. 4) each year that we have been based at St. Augustine. Successive heads of Zoology have been very supportive of our visits. This has been critical to the kind of work we do, often bringing frogs and tadpoles back from the field to observe in controlled conditions. Much tropical field zoology is done in primitive conditions, with limited access to electricity and scientific facilities, but our base at UWI allows quite sophisticated work. For example, in 2011, a student came up with an idea that required preservation of many small samples at -20°C and transportation of them to Glasgow. Discussion with unfailingly helpful technicians gave her access to a -80°C fridge, and plentiful supply of eppendorf tubes and dry ice for transportation. The interaction has not simply been about providing facilities. Although most UWI students are on vacation when our expeditions occur, over the years, a good number of UWI students have joined us in some of our activities, and we have also done collaborative work with UWI staff. The Glasgow-Trinidad connection began with Robin Bruce, a Glasgow graduate, joining the UWI staff: it has recently continued with Mike Rutherford, another Glasgow graduate who first visited Trinidad on a Glasgow expedition, joining the UWI staff as Zoology Museum Curator.

Some of our Trinidad expeditions have been based at the Asa Wright Nature Centre's field station 'Simla', formerly run by the New York Zoological Society. Ronnie Hernandez has been a great help to expeditions based at Simla, and our students have often provided educational sessions for schoolchildren at AWNC.

Our interactions with the Trinidad and Tobago Field Naturalists' Club have been somewhat limited, largely because of the timing of our visits to Trinidad. We have given occasional talks to the Club, contributed papers to *Living World*, and we also took part in the 2004 symposium commemorating the life of Peter Bacon (*Living World* Supplement, 2004), with Suzanne Livingstone organising the session on marine turtles.

In Tobago, early expeditions worked with the Crusoe Reef Society to investigate the state of Tobago's coral reefs. Our longest-term Tobago collaboration has been with SOS Tobago, helping to monitor marine turtle nesting. This arose out of a period when Glasgow University's tropical marine ecology course took place in Tobago: contacts were made by Sarah-Jane Judge, a student on the course in 2003, and the first expedition took place in 2004. Glasgow students have been a considerable assistance to SOS Tobago, since it is very hard to monitor all the beaches throughout the long nesting season (March to

July) with local volunteers only.

CONCLUSION

I am now officially retired from my post at the University of Glasgow, but continue in an honorary capacity. I certainly hope that the link developed between Glasgow and Trinidad over these last two decades will carry on. It has clearly had many benefits – to student participants in terms of experiences of tropical biology and the chance to do serious science; to knowledge of Trinidad and Tobago's biodiversity; to the effort to conserve wildlife in these challenging times. In science, any piece of work tends to generate new questions, and there clearly remains a great deal more to learn about Trinidad and Tobago's wildlife. I anticipate that interactions between Glasgow and Trinidad and Tobago will continue to contribute to that learning for many years to come.

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