LIVING WORLD

Journal of The Trinidad and Tobago Field Naturalists' Club

2012

THE TRINIDAD AND TOBAGO FIELD NATURALISTS’ CLUB

The Trinidad and Tobago Field Naturalists’ Club was founded on 10 July, 1891. Its name was incorporated by an Act of Parliament (Act 17 of 1991). The objects of the Club are to bring together persons interested in the study of natural history, the diffusion of knowledge thereof and the conservation of nature.
Monthly meetings are held at St. Mary’s College on the second Thursday of every month except December.
Membership is open to all persons of at least fifteen years of age who subscribe to the objects of the Club.

Mission Statement
To foster education and knowledge of natural history and to encourage and promote activities that lead to the appreciation, preservation and conservation of our natural heritage.

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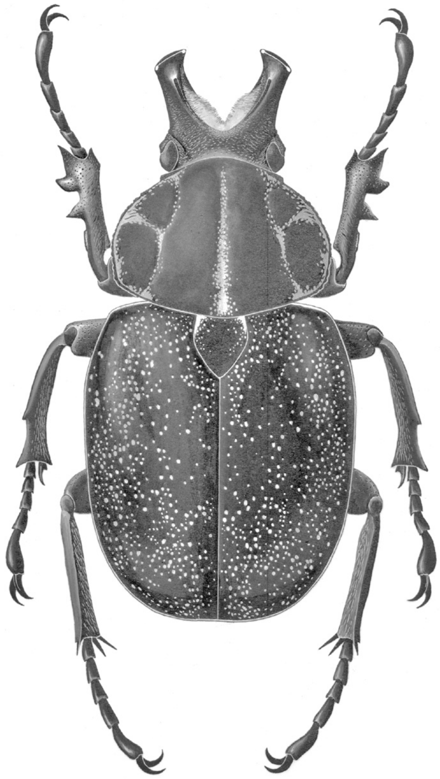

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Editorial

The 2012 issue of Living World is dedicated to Dr. Julian S. Kenny, former Professor of Zoology, University of the West Indies and a long-standing and influential supporter of the Journal. We are pleased to include a tribute from Emeritus Professor Julian Duncan. Roger Downie provides a sample of Dr. Kenny's influence and encouragement in an account of the 'Biodiversity Connection' between Glasgow University and Trinidad and Tobago. And finally, we have a reflection by John Murphy and Roger Downie that despite the work done by Kenny and his predecessors, there is some work on amphibians and reptiles left to do.

In this issue, we publish five Research Papers and a record thirteen Nature Notes spanning a wide range of taxa and life habits. However, in this issue we have no paper on plants; but fortunately our Guest Editorial this year on the Darwin Initiative comes from Yasmin Comeau, Curator of the National Herbarium and our flora is given recognition.

Victor Quesnel and David Stradling provide "Evidence for the Function of the Eye-spots in the Butterfly genera *Caligo* and *Eryphanis."* and thus conclude a lifelong consideration on the subject initiated by an off the cuff comment and publication in 1976.

Matthew Cock has provided us with the 19th part of his account of the Skipper Butterflies of Trinidad, an account which has benefited from our improved printing quality and colour. Matthew Cock has also collaborated on two Nature Notes, one with J.M. González describes the moth *Corybantes mathani* (Castniidae) a new record for Trinidad and one with Charles De Gannes on the biology of the Nymphalid *Memphis pithyusa morena.*

The Arachnida are well represented in this issue of Living World in an account of the Harvestmen of Tobago by Victor Townsend and others. Jo-Anne Sewlal notes two spider specimens listed from Trinidad in the database of Field Museum, Chicago, USA, of families not previously collected in Trinidad. She also observes a case of apparent "parental care" of eggs by the spider *Azilia vachoni.* Still with arachnids but of the parasitic kind, we have a paper on the tick infestations of *Rhinella marina* by J.D. Burgon *et al.*, and Elisha Tikasingh writes about Laelapid mites from small mammals in Trinidad.

The remaining contributions are a very mixed bag. We have an account of free-living nematodes from a natural oil seep at La Brea, Trinidad by J.F. Gobin *et al.*; a new wasp for Trinidad by Allan Hook and the Status of Four Aquatic Crustaceans from Grand Cayman, West Indies by David Bass. Ryan Mohammed and Mike Rutherford record two new gastropods from Trinidad.

A few contributions relate to the islands and the sea surrounding Trinidad's north-west peninsula. Mike Rutherford and M. Charran note the occurrence of two species of sea cucumbers; from Williams Bay *Holothuria cubana* and the sea off Cocorite *Parathyone suspecta.* Mike Rutherford describes the feeding behaviour of a giant centipede *Scolopendra gigantea* captured on Chacachacare Island, and Stevland Charles *et al.* provide the first record of an Opossum *Didelphis marsupialis* from Gaspar Grande (Gasparee) and four reptiles from Gasparillo Island also known as Centipede Island.

The issue includes the ninth report of the Trinidad and Tobago Rare Birds Committee in which 54 records of rare birds were considered. Male hummingbirds generally take no part in nest-building or parental care. We have one note by Michelle Rochford of a hummingbird in male plumage sitting on a nest.

In 2004 the proceedings of a conference on Caribbean Island Natural History titled *The Nature of the Islands* were published as a supplement to the Living World. In 2011 this practice continued with two supplements published. The Proceedings of the 1st Research Symposium of the Department of Life Sciences of the University of the West Indies, St. Augustine, 7-8 April, 2011 were published as Supplement 1 to the Living World 2011. In August, 2011 the Bolivarian Section of the International Union for the Study of Social Insects held their 8th Biennial General Meeting at the University of the West Indies, St. Augustine. These proceedings were published as Supplement 2 to the Living World 2011. The Editor looks forward to additional supplements of this nature.

The Journal continues to receive good support from professional researchers and knowledgeable naturalists and the Editor thanks all contributors, reviewers, and sponsors for their contributions.

GLW

Cover Photograph

The success of the Cattle Egret *Bubulcus ibis* in Trinidad is well documented. It was first recorded in Trinidad in 1951 and reached Tobago in the early 1960s. It soon became the most abundant heron in Trinidad. Their success was in part due to their association with grazing animals. They walk alongside a cow or buffalo, and feed on insects disturbed by the movement. When Cattle Egrets first arrived in Trinidad this was a vacant feeding niche. They soon adapted to feeding along tractors and other machinery. Some individuals have learnt that fire also triggers grasshoppers into rash flights making them easy prey. This one was photographed by G. White at Nariva Swamp as it made use of a fire set by a farmer to clear the land.

Guest Editorial: Using the Dead to Inform the Living: Investing in Biological Collections

Biological collections preserved as dried or wet plant or animal specimens stored in herbaria or museum cupboards, jars or display cabinets represent a snapshot of a particular moment in time which can tell a story or solve a problem. These seemingly *dead* specimens, if well maintained, serve as a valuable 'biological clock' linking the past with the present and the future.

Trinidad and Tobago have a long recorded history of plant exploration dating from the arrival of Christopher Columbus in 1498. Over the centuries, countless specimens from Trinidad and Tobago have been removed and deposited in major herbaria in Europe and North America. It is this historical propensity for collecting and documenting specimens that gave rise to the National Herbarium of Trinidad and Tobago (TRIN) which originated with the Royal Botanic Gardens, Port-of-Spain established in 1818. J. H. Hart, fifth Superintendent of the Botanic Gardens, formalised the herbarium in 1887 by salvaging some of the specimens from his predecessors. The earliest specimens rescued from these early collectors dating from 1842 are integrated with the extant collection.

The vascular flora of Trinidad and Tobago dominates the collections with a smaller regional sample. There are good representative samples of marine algae, mosses and liverworts. The fungi and lichens are underrepresented, but research is in progress on lichens as bio-indicators of forest health. These sampled specimens (vouchers) will become the primary reference collection for future research. The *value* of all these collections can be readily assessed by (i) the extent to which they have been consulted by researchers, students and the general public seeking information on the flora followed by (ii) dissemination of this knowledge through scholarly publications, popular writings and/or oral presentations to reach the widest audience.

The herbarium provides a plant identification and information service. Identifying over 6,800 specimens for the public over the last ten years (2002-2012), it involves challenges such as: identification of seeds on a victim's clothing or endorsing marijuana plants (*Cannabis sativa*) seized by the police; a medical practitioner having a sick child ingesting unfamiliar seeds and subsequently identified as rubber seeds (*Hevea brasiliensis*) was treated for probable cyanide poisoning; and checking a packet of finely powdered Cat's Claw tea from The Food & Drug Division of the Ministry of Health are examples of the work of the herbarium. Scholars worldwide, in any field involving plants, must seek out a herbarium. Similarly, two local publications come to mind, *Medicinal Plants of Trinidad and Tobago* (Seaforth *et al.* 1982) and *Dictionary of the English/Creole of Trinidad and Tobago* (Winer 2009) relied heavily on our herbarium.

Our recent research involved a botanical inventory undertaken from 2005-2008 to develop a **Biodiversity Monitoring System for Trinidad and Tobago,** in collaboration with Oxford University, U.K. and the Forestry Division, under the Darwin Initiative (this was done concurrently with refurbishment of the herbarium). This botanical survey produced over 22,000 specimens of which 90% were identified using the reference collection. The results of this comprehensive study, soon to be published, have (i) identified biodiversity 'hot spot' areas, (ii) assessed the status of rare, threatened and endemic species, and (iii) formed the basis for a new vegetation classification for Trinidad and Tobago.

In 2009, we initiated a *student internship programme* with the University of the Southern Caribbean (USC) Maracas, Trinidad. This programme is designed to give students an opportunity to volunteer their time while gaining hands on experience working in the herbarium. Thirty-one students have participated in the programme mounting over 3,000 specimens from the huge backlog of specimens accumulated over the years. The impact on USC students' learning has been twofold: increasing awareness of the richness of the local flora and leaving a legacy behind with their mounted specimens. A long standing partnership continues with *The Trinidad and Tobago Field Naturalists' Club* whose membership is dedicated to the study of our natural history. Members have made good use of the herbarium to identify plants from their field trips and have added valuable specimens to the collection.

Visitor records from 1970-1979 amounted to merely 256 compared to 1980 to 1990 totalling 1568, increasing to 1821 between 2002 and 2012. Our visitor's book clearly shows an increasing trend particularly school groups ranging from kindergarten to tertiary level institutions requesting lectures and a tour of the facilities.

More importantly, our herbarium is supported as 'a national asset' by the Government of Trinidad and Tobago. Today the collection is approximately 70,000 specimens and is projected to increase to 100,000 in the next five years, if research in ecology, conservation and monitoring of our biodiversity continues to be supported and funded at the present rate. According to Pyke and Ehrlich (2010) "*.......the level of research attempting to use biological collections in museums or herbaria in an ecological/environmental context has risen dramatically during about the last twenty years.*" We concur with this observation where research activities and public awareness have increased access to our collection aimed at conservation of our biodiversity.

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Julian Stanley Kenny, 24 January, 1929 – 9 August, 2011: An Appreciation

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Julian Stanley Kenny made his first appearance in our time and space on 27 January, 1930, the 3rd of 7 children born to Anthony and Louise Kenny.

The opening line of a popular song states, *"It only takes a spark to get a fire going."*

To a young lad who had traditionally thought that all plants grew from the soil, an orchid plant growing on a piece of tree trunk sparked a curiosity in living things; a curiosity that developed into a fire of inquiry into the workings of the natural world around him, a curiosity that was to be one of his distinguishing characteristics.

Jake as he was more popularly called, navigated his way successfully through the education maze, gaining a Degree in Zoology from the University of Toronto in Canada. On his return to Trinidad and Tobago, he took a position with the Fisheries Division of the day, a position that necessitated his travelling through the length and breadth of the islands and afforded him the opportunity to acquaint himself with their natural history. During this period he met and married the former Miss Joan Wedderburn, a happy union that produced a son – Peter – and a daughter – Philippa. After some years with the Division, he left for London where he completed his doctorate at Birkbeck College, London University and on his return to Trinidad in 1963, he took up a post as the sole Zoologist appointed to the fledgling College of Arts and Sciences at the St. Augustine Campus of the University of the West Indies.

With his interest in natural history in general, it is not surprising that at the U.W.I. he veered in the direction of ecology – the study of the interaction among plants, animals and the environment in which they exist – and a die-hard environmentalist was born. He spearheaded research that highlighted the ecological dynamics of some of the natural areas of the islands, including savannas, wetlands, cave systems, marine systems and coral reefs among others. As a result of the detailed information he had on these systems he became concerned with the degree of degradation he saw taking place in the name of progress: quarrying in the Aripo Savanna; removal of mangroves from wetlands; use of fishing gear that was deleterious to maintenance of fish stocks, and he championed any reasonable cause that sought to lead to a protection of the environment. He thus supported many an NGO among them Fishermen and Friends of the Sea.

His interest in conservation went beyond the natural environment to the built environment. He was passionate about the preservation and, where necessary, the restoration of buildings, particularly those of historical interest. His efforts to have Nelson Island restored and be named a heritage site appears to have found little sympathy with the powers that be.

With his wide knowledge of and care for the environment, it was no surprise that when he was appointed an Independent Senator, he would become principally the voice for the environment in the Senate.

His expertise in matters environmental was clearly recognised in his appointment as:

- Advisor to the Inter-ministerial Committee on the Law of the Sea convention
- Chairman of the Board of the Institute of Marine Affairs
- Member of the Cabinet appointed Committee that drafted the National Parks legislation, among others.

Among the posts he held in the private sector was Chairman of the Guardian Wild Life Fund.

In the year 2001 he was appointed chairman of an ad hoc committee to spearhead the establishment of a Biodiversity Centre - one of his dreams for the country - at the St. Augustine Campus of the University of the West

Indies. Under his chairmanship significant progress towards the realisation of the dream was made until the project, for reasons still not clear to me, appears to have been put on ice.

His last official appointment was as Chair of the Board of the EMA, a post from which he resigned after 6 months of effort. As Paolo Kernahan puts it in a tribute paid after his passing, and I quote:

"He was not afraid to show who he was backing in that fight and this was made clear in his last act of defiance against this administration for its failure to meaningfully address the threat posed by rampant quarrying."

Wordsworth, in his Ode on *Intimations of Immortality,* wrote:

"What though the radiance which was once so bright
Be now for ever taken from my sight,
Though nothing can bring back the hour
Of splendour in the grass, of glory in the flower;
We will grieve not, rather find
Strength in what remains behind."

What remains behind? Jake has left us a legacy of concern for the preservation of the environment, and a tireless effort to staunch further degradation. A proverb that has been attributed to Native Americans or variously to Ralph Waldo Emerson or David Bower, states that:

"We do not inherit the earth from our ancestors,
But borrow it from our children."

If we can but gain strength from what he has left us, his living will not have been in vain and we will be able to pass to generations yet unborn, at least a percentage of that which we borrowed from them.

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The Editorial Committee thanks the following persons who took time off from their busy schedule to review papers over the last five years.

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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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Evidence for the Function of the Eye-spots in the Butterfly Genera *Caligo* and *Eryphanis* (Lepidoptera: Nymphalidae: Morphinae: Brassolini)

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ABSTRACT

Direct observations of seven predatory attacks by the geckonid *Thecadactylus rapicauda* on butterflies of the genera *Caligo* and *Eryphanis* are reported. Two hundred and nine individuals of these butterflies were examined and the probable causes of wing damage classified. Of those examined, 57% showed wing damage of which 60% was consistent with attack by *Th. rapicauda.* The data support the deflection hypothesis; that these butterflies benefit from the "mimetic false head" through disoriented attack. Additional damage was observed suggesting attack by a larger predator. The behaviour of the predator towards the "mimic" is discussed. We propose that the eye-spots on these butterflies benefit the bearers through intrusion into the behavioural interactions between arboreal lizards. The possible mimicry of other saurian models by the genus *Caligo* is discussed.

Key words: mimicry, deflection hypothesis, geckonids, *Thecadactylus.*

INTRODUCTION

The conspicuous eye-spots on the hindwing undersides of the butterfly genera *Caligo* and *Eryphanis* have led to the common name of 'owl butterflies'. Such eye-spots are found on butterflies, reptiles, birds and fish where they function as a mode of interspecies communication and represent a form of auto-mimicry in many species (Stevens 2005), although the precise evolutionary function of eye-spots in many species is not understood or has been mis-interpreted in the past. The adaptive value of the very conspicuous eye-spots on the hindwing undersides of *Caligo* and *Eryphanis* has been the subject of much speculation over the past century (Thayer 1909; Cott 1940; Blest 1957; Kirkpatrick 1957; Barcant 1970; Linsenmaeir 1972; Stradling 1976; de Vries 1987; Stevens 2005).

Both Thayer (1909) and Stradling (1976) considered that 'owl butterfly' was a misnomer, the latter pointing out that both eye-spots would only be simultaneously visible (representing the owl face) in cabinet mounted specimens. Also, that the eye-spots and the surrounding underside markings on each side, resemble the profile of an amphibian or reptilian head. Stradling (1976) pointed to the tree frogs *Hyla* as the models for *Caligo* and the arboreal lizards *Anolis* as the models for *Eryphanis* and suggested that these patterns might benefit their bearers in some way by intruding in the behavioural interactions of diurnal lizards that inhabit tree trunks where the butterflies rest in the daytime. The pattern might therefore appear as either a territorial rival or potential mate. Whichever, it would confuse the potential assailant and result in a non-predatory response. In addition, the eye-spots could confuse assailants as to the orientation of their prey, rival or mate. This "deflection hypothesis" as it is now known has been suggested by several authors (Poulton 1890, 1908; Cott 1940; Blest 1957; Wickler 1968; and Robbins 1980).

Hill and Vaca (2004) studied marginal wing damage in the genus *Pierella* of the Nymphalid subfamily Satyrinae. They found that the marginal parts of the wings bearing deflection marks (eye-spots) are relatively weak and, having an increased tendency to tear when grasped by a predator, are consistent with the deflection hypothesis. *Pierella hyalinus* is the only member of this genus found in Trinidad.

METHODS

Study species

The four species, *Caligo brasiliensis minor* Kaye, *C. illioneus saltus* Kaye (Fig.1a), *C. teucer insulanus* Stichel and *Eryphanis automedon* Cramer (Fig. 2) (Casagrande 2004), have wide distributions in tropical South and Central America. All occur in Trinidad and are common at Haven Hill Farm, Leotaud Trace near Talparo (10^{o} 31' 30.06" N; 61^{o} 16' 36.92" W) where most of the observations reported here were made.

The gecko *Thecadactylus rapicauda* (Houttuyn) (Fig. 1b), ranges from Mexico through Central and South America to southern Amazonas, and northward through the Lesser Antilles as far as Necker in the Virgin Islands (Peters and Donoso-Barros 1970; MacLean 1982; Bergmann and Russell 2007). *Th. rapicauda* is a nocturnal gecko with a maximum snout to vent length (SVL) of 121 mm and a tail length shorter than the SVL for both sexes (Murphy 1997). In the field the sexes are indistinguishable unless the female is visibly gravid. The colour is a mixture of grey and various shades of brown in a variable complex of blotches that can be altered to match the background, so that the lizard is normally well camouflaged. It is an ambush predator whose normal locomotion is slow and steady (Quesnel 2004) and feeds on a wide range of arthropods besides *Caligo*, including

Fig. 1. Computer superimposition c) of the mimetic pattern of *Caligo illioneus* a) on photographic profile of *Th. rapicauda* b). The level of mimicry is greatly enhanced by the secondary smaller 'eye-spot', representing the lizard's tympanum, in addition to the highlighted profile of the head and shoulder region. The representation in (Fig. 1b) is diminished because the gecko was photographed in bright light with direct flash rather than natural overhead lighting. For this reason the pupil of the eye is reduced to a slit and the 'concavity' of the tympanum lost.

other Lepidoptera (Vitt and Zani 1977; Quesnel 2008). It is common in Trinidad where it lives on the trunks of forest trees. Bergmann and Russell (2007) point out that it is the only nocturnal arboreal lizard over much of its range and that also it is far larger than any other continental geckonid.

Although principally nocturnal, it is sometimes active well into daylight hours, and its calls have been heard at all hours of the day and night (Quesnel 2008). After dark it is attracted to the vicinity of artificial lights, where it preys upon the attracted insects. It eats a wide range of arthropods as well as some small saurian vertebrates (Murphy 1997; Quesnel 2008).

Caligo and *Eryphanis* species are crepuscular in activity (Quesnel 2003) and, attracted by domestic lights, frequently enter buildings. Over a period of eight years, observations were made of 142 butterflies that entered Haven Hill Farm where a fluorescent kitchen light was left on. The butterflies settled on the oiled wood walls or ceiling where they could easily be caught or observed. A total of 105 individuals was caught and the amount of wing damage recorded (see below), before being released outside. Forty-four additional individuals were caught resting on other buildings or in the surrounding forest. The house at Haven Hill Farm is occupied by about twenty *Th. rapicauda* which have become habituated to human presence and tolerate close observation (0.5 m).

Classification of wing damage

Wing damage was classified as being due to a) *Th. rapicauda* attack; b) possibly *Th. rapicauda* attack; c) attack by some other predator; and d) non-predator hazards. The key evidence was the bite shape of *Th. rapicauda* as illustrated in Fig. 3a which corresponds closely to much of the observed range of damage to *Caligo* wings (Fig. 3b-l). The failure of the attack to produce a complete bite mark (Fig. 3d,e,h) could be due to either the rapid escape reaction of the butterfly or the fact that the front teeth of the *Th. rapicauda* are about half the size of the back teeth. In a small number of butterflies the curved outline of a mouth twice the size of that of *Th. rapicauda* implies the lizard *Tupinambis teguixin* (Linnaeus) whose adult size is SVL 333 mm.

Direct observations

During this study a total of seven direct attacks of *Th. rapicauda* on resting *Caligo* and *Eryphanis* butterflies was recorded. Detailed observations were made on two of these.

RESULTS

The hindwing underside pattern, including the eyespots, of the three species of *Caligo* occurring in Trinidad bears a striking resemblance to the head profile of the gecko *Th. rapicauda* (Fig. 1a-c). Although a saurian head profile is also apparent on *E. automedon* (Fig. 2), it is significantly different from that on these three *Caligo* species and does not share a close resemblance to *Th. rapicauda*.

Fig. 2. Underside patterns of *Eryphanis automedon.*

Accumulated records representing 209 specimens (Table 1) include six direct observations of attack on *Caligo* and *Eryphanis* by the gecko *Th. rapicauda* in which the butterfly was eaten and one in which it escaped. The rest include undamaged ones and specimens for which wing damage has been subjectively classified as to its cause according to the scheme given in Fig. 3 and Table 1.

Direct observations

Detailed notes of two observed attacks by *Th. rapicauda* were made in the lighted room described and five other attacks were witnessed in part. Six attacks resulted in the prey being eaten and in the other it escaped. In four of the six cases that resulted in ingestion, the butterfly was attacked from the front, three being seized by the base of the forewing and one by the head and thorax. The three remaining cases involved the butterflies being attacked from the rear and one of these escaped.

Ingestion may include the wings as well as the body of the prey, although discarded wings were noted for two of the specimens that had been eaten. Stalking is a protracted affair, with the geckos spending 40-75 minutes in close proximity (10-35 cm) to the prey. In the case where the butterfly escaped, the gecko orientated to the butterfly's eye-spot, wiping its own eyes and moving its head to assist in aligning itself prior to attack. The final strike was clearly at the mimetic eye-spot on the butterfly and resulted in a typical loss of wing fragment (Fig. 3b).

Table 1. Classification and frequency of wing damage in *Caligo* and *Eryphanis* spp. observed in this study.

Damage Category	Data for both *Caligo* spp. and *Eryphanis automedon.*	Data for *Caligo* spp. only.	Data for *Eryphanis automedon* only.	Categories 2 and 4 ascribed to category 3.	Category 4 ascribed to category 5.	Category 2 ascribed to category 1 and category 4 ascribed to category 5.	Categories 2 and 3 ascribed to category 1 and category 4 ascribed to category 5.	All damage ascribed to category 1.
Consistent with attack by *Th. rapicauda* (Figs. 1b, 1c, 1d, 1e).	71	66	5	71	71	86	98	119
Possibly due to *Th. rapicauda* attack (Fig 1f).	15	12	3	0	15	0	0	0
Possibly due to a predator other than *Th. rapicauda* (Figs. 1g, 1j, 1k).	12	11	1	48	12	12	0	0
Due to non-predator hazards (Fig. 1l).	21	21	0	0	0	0	0	0
Undamaged individuals.	90	83	7	90	111	111	111	90
Total	**209**	**193**	**16**	**209**	**209**	**209**	**209**	**209**
Proportion (%) attacked by *Th. rapicauda* and escaped.	34.0	34.2	31.3	34.0	34.0	41.1	46.9	56.9

Wing Damage

Wing damage for 193 *Caligo* and 16 *Eryphanis* individuals was recorded (Table 1). This identifies the gecko *Th. rapicauda* as an important predator of these butterflies in Trinidad, with 34% of wing damage attributed to this species. The data are summarised in Table 2 and show 60% of damage commensurate with attack by *Th. rapicauda*. Fourteen butterflies bore evidence of more than one attack (Fig. 3i, Fig. 3j) and in 12 butterflies, bite marks were consistent with attacks by juvenile *Tu. teguixin* (see discussion).

Table 2. Summary of wing damage recorded from 193 *Caligo* and 16 *Eryphanis* individuals.

	Caligo spp.	*Eryphanis automedon*
Undamaged individuals (%).	43	44
Damaged individuals (%).	57	56
Damage attributed to *Th. rapicauda* (%).	35	31
% of damaged individuals attributed to *Th. rapicauda.*	60	56
Damage attributed to *Tu. teguixin* (%).	6	6
Damage attributed to other causes, wear & tear (%).	11	0

DISCUSSION

What is the model for the pattern on the wing undersurface of *Caligo* species? Stradling's (1976) initial interpretation was that it represented a frog of the genus *Hyla*. In this study we present new evidence that in Trinidad, the eye-spots of *Caligo illioneus* closely resemble the head profile of one of its own predators, the gecko *Th. rapicauda* and propose that *C. illioneus* mimics *Th. rapicauda*. The relative sizes of eye-spot and ear-spot (tympanum) and their positioning strongly suggest this. We also present data showing that in the field, a great many butterflies of this genus bear marks indicating attacks to the rear margin of the wings by this gecko, thus supporting the deflection hypothesis.

In his review of eye-spot mimicry, Stevens (2005) rightly points out that it is unsatisfactory to consider the perception of these patterns from a human perspective but then proceeds to consider them from an essentially avian point of view. Here we have evidence that for *Caligo* at least, the principal target is a gecko.

Since *Th. rapicauda* in its feeding will strike at a simple eye-spot, one may ask what is the advantage to the butterfly of such a detailed imitation of a *Th. rapicauda* head. One possible explanation is that on the curved surface of a tree trunk, the gecko predator may first see a

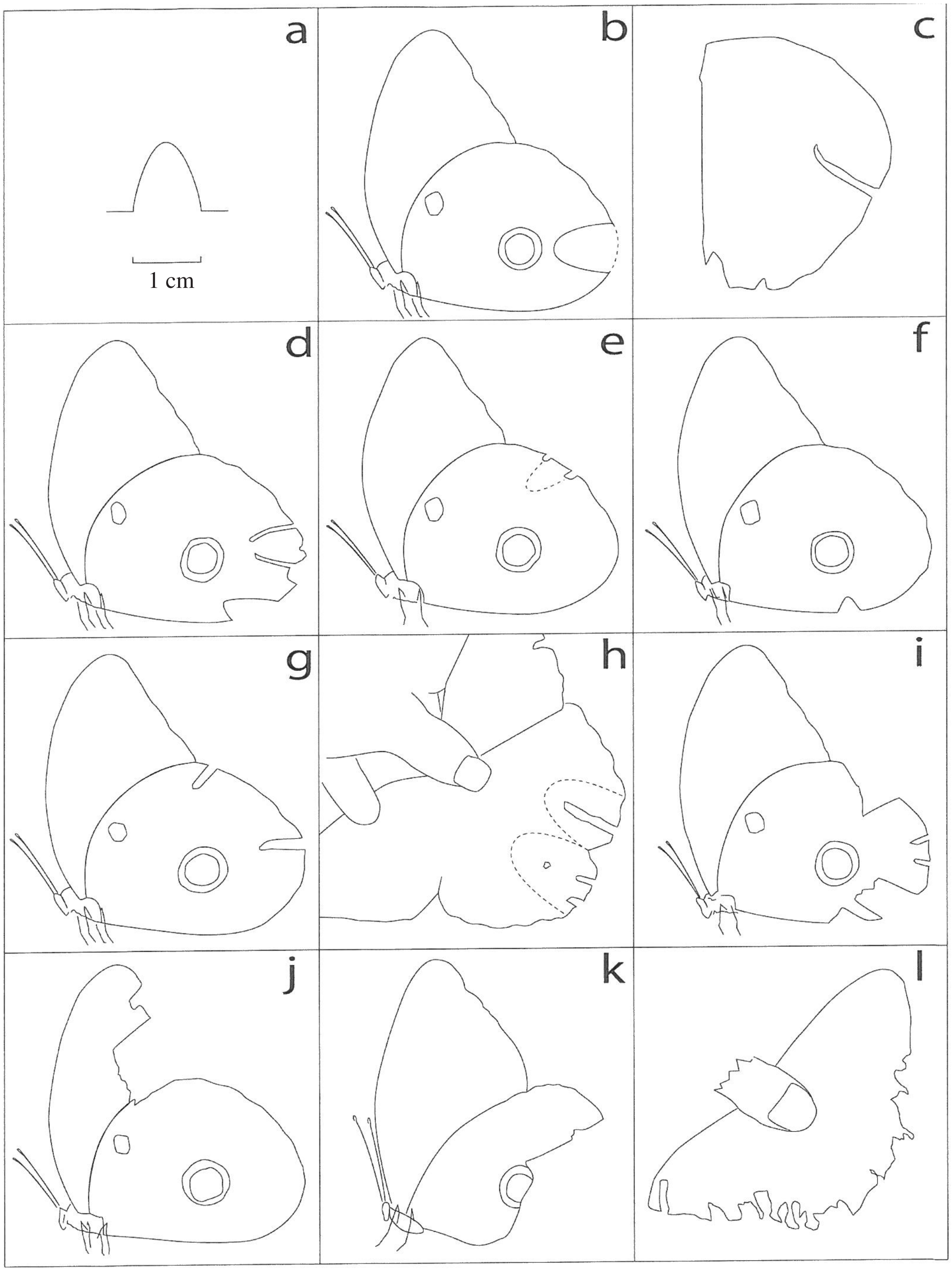
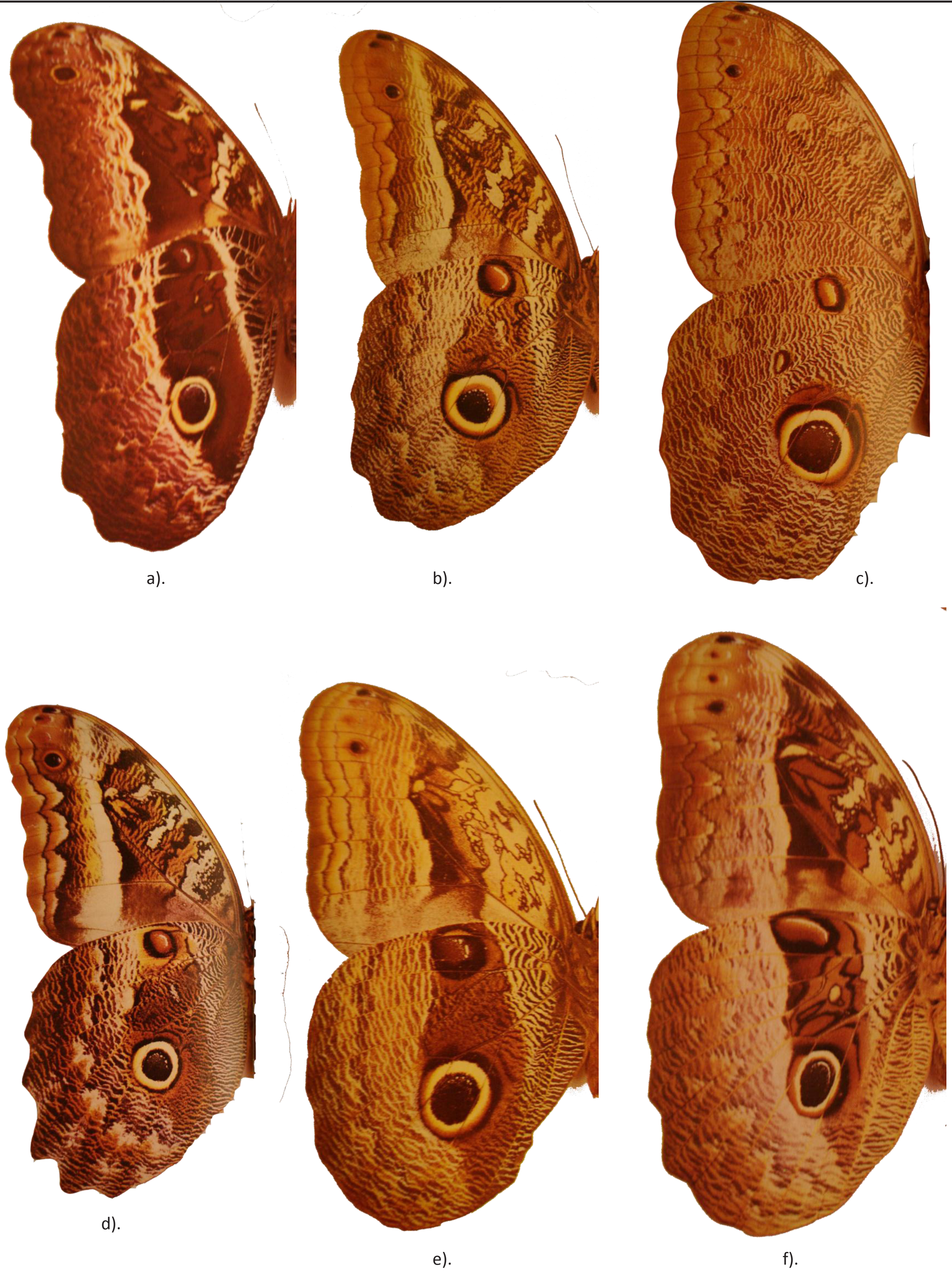


Fig. 3. Types of damage recorded from wings of *Caligo* spp. and *Eryphanis automedon* (mostly the former) with probable interpretations. **a)** Outline of 'bite' of *Th. rapicauda* produced by drawing around skull. **b)** Typical damage inflicted by *Th. rapicauda* - Category 1 (dotted line represents edge of wing if it were present). **c)** Cut in wing made by mandible and maxilla of one side of *Th. rapicauda* mouth - Category 1 (butterfly flew before complete closure of predator's mouth). **d)** Typical damage inflicted by *Th. rapicauda* - Category 1. Lower bite - wing fragment removed; Upper bite - butterfly flew before jaws fully closed. **e)** Two nicks in wing from back teeth of *Th. rapicauda* - Category 1. Butterfly flew before jaws fully closed. **f)** Small area of wing removed - Category 2. Damage caused by tip of predator's mouth closing on wings as prey flew away. Probably inflicted by *Th. rapicauda,* but possibly a bird. **g)** Damage inflicted by a predator other than *Th. rapicauda* - Category 3. **h)** Typical damage inflicted by both *Th. rapicauda* and a larger predator (probably *Tu. teguixin*) - Category 1. **i)** Evidence of 3 attacks - Category 1. 1) *Tu. teguixin* with wing-tearing before complete closure of mouth; 2) *Th. rapicauda* damage as in e); 3) Possible attack by *Th. rapicauda* with wing-tearing. **j)** Damage inflicted by *Tu. teguixin* - Category 3. **k)** Damage inflicted by *Tu. teguixin* - Category 3. **l)** General wear and tear from non-predator hazards - Category 4. This type of damage could obscure that caused by *Th. rapicauda* as in e) and f).



a). b). c).

d). e). f).

Fig. 4. Underside patterns of various *Caligo* species. **a)** *Caligo oberthurii* Deyrolle ssp. *phokilides* Fruhstorfer (Peru). **b)** *Caligo idomeneus* (Linnaeus) ssp. *idomenides* Fruhstorfer (Peru). **c)** *Caligo eurilochus* (Cramer) ssp. *livius* Staudinger (Peru). **d)** *Caligo superbus* Staudinger ssp. *agamemnon* Weymar (Ecuador). **e)** *Caligo placidianus* Staudinger (Peru). **f)** *Caligo beltrao* Illiger (Brazil).

resting butterfly from close quarters and react to the mimetic pattern as it would to a rival or mate with a prefatory display rather than be intimidated as it might to a predator of itself (Stevens 2005). In this case the butterfly may have time to escape. The Fig. 1a in Stevens (2005) is that of a cabinet mounted specimen in which the pattern surrounding the eye-spot is omitted and therefore fails to present the full extent of the pattern.

Alternatively, the gecko may by stealth, approach close enough to remain undetected. Escape for the butterfly then depends entirely on misorientation to the mimetic eye, (deflection hypothesis), the attack having been mounted at the mimetic, rather than the real head of the butterfly. Other genera of brassolini such as *Opisphanes* also bear eye-spots but without the associated pattern that suggests a reptilian head profile. This is also true of some *Caligo* species, e.g. *C. eurilochus livius* Staudinger (Fig. 4c). The evolutionary addition of patterns representing a tympanum and demarking the head profile of a gecko reinforce the misorientatory effect by indicating that the snout of the mimetic gecko head is at the anal angle of the butterfly's hindwing. Furthermore, the representation of the tympanum includes a white crescentic area implying a three dimensional concavity, although the details of its orientation in relation to ambient light in natural conditions is not clear and calls for further investigation. We suggest that such a stepwise elaboration would change the perception of the mimetic pattern by a stealthy predator from a potential prey item to another individual of its own species. This in turn might result in an intraspecific interaction rather than a predatory one. Such behaviour would be broadly divided into competitive/territorial between individuals of the same sex, and courtship/mating between individuals of the opposite sex. *Thecadactylus rapicauda* individuals have been observed head to head with jaws locked together rolling over and over on the floor (VQ, pers. obs.). Presumably the combatants were both male and this aggressive behaviour resulted in a bite targeted at the head. Preliminary courtship behaviour by male *Th. rapicauda* consists of a bite to the female's neck (Quesnel 2006). Whichever sex the mimic presents, the response is likely to be a bite to the perceived head region. Groups of two or three *Th. rapicauda* consisting of females, or females with one male, may often be found in a daytime retreat. This implies that intraspecific interactions between males are frequent. Thus the more elaborate mimic of the predator itself, reinforces the misdirected attack whether the butterfly is perceived as prey, rival or mate. This is in broad agreement with the suggestion by Stradling (1976) that these butterflies benefit through an intrusion into the behavioural interactions between arboreal lizards.

Direct observations confirm the identity of the geckonid lizard *Th. rapicauda* as a predator of adult *Caligo* and *Eryphanis* butterflies. During attack, the prey is stalked slowly, allowing plenty of time for the predator's attention to be diverted by the eye-spot. This is supported by the data presented here which show survival of 34% of butterflies with wing damage commensurate with attack by geckonid lizards (Table 1). With all undamaged individuals included, escape from capture through misdirected attack amounts to a minimum of 41%. Of the five butterflies exhibiting evidence of attack by the larger *Tu. teguixin* predator, three bore damage to the forewings. This implies that the predator was not diverted by the eye-spot.

If the patterns of these three Trinidad *Caligo* spp. are the result of natural selection to mimic their principal predator *Th. rapicauda,* why is the *Eryphanis automedon* eye-spot pattern so different and what is the model? Stradling (1976) suggested *Anolis chrysolepis* (Troschel) as the model but this is unlikely due to its small size and shape. For *E. automedon* then, a hypothetical lizard is the more important predator in some other part of its range. Trinidad, an island of 4828 km^2, represents a small proportion of the range of these Neotropical genera which contain 21 species of *Caligo* and five species of *Eryphanis* (D'Abrera 1987; Casagrande 2004) and a corresponding 116 Neotropical species of *Anolis* (Peters and Donoso-Barros 1970). By contrast, the three species of *Caligo* in Trinidad all seem to have the same model, *Th. rapicauda,* for the lizard pattern. Furthermore, Bergmann and Russell (2007) consider that there are only two species of *Thecadactylus* throughout its enormous Neotropical range albeit with extensive local variability of *Th. rapicauda*.

At least five other species have lizard-like patterns on their hindwings (Fig. 4) which may represent local variants of the model, while species such as *C. eurilochus livius* (Fig. 4c) cited above, lack a saurian head profile surrounding the eye-spot altogether and may represent an ancestral form.

If the mimicking of lizard predators has driven speciation in these butterflies, how important is the precision with which the model is mimicked? The five species figured (Fig. 4a-e) show considerable variation in the detail of the patterns surrounding the eye-spot. Do they represent different models? The experimental exposure to gecko attack of butterflies from which the mimetic pattern has been wholly or partly erased could well throw light on this. None the less, the striking implication of the present data to the power of natural selection calls for experimental corroboration. Does attack by *Th. rapicauda* demand a more elaborate mimetic pattern than that found on *C. eurilochus livius*? If these butterflies are mimicking several different saurian models, the implication is that the natural selection is finely tuned. The complex network of interactions between these butterflies and their predator models undoubtedly merits more investigation.

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The Skipper Butterflies (Hesperiidae) of Trinidad.
Part 19. Hesperiinae, Moncini: the Remaining Genera with Pale Spots: *Cymaenes*, *Cobalopsis*, *Arita*, *Lerema*, *Morys* and *Tigasis*

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ABSTRACT

Trinidad and Tobago skipper butterflies (Hesperiidae) of the tribe Moncini (genera *Cymaenes*, *Cobalopsis*, *Arita*, *Lerema*, *Morys* and *Tigasis*) are treated and the adults illustrated. Details are given of the taxonomy, history, identification and biology of the 14 Trinidad species in these genera, of which two species also occur in Tobago. Partial life histories of *Cymaenes tripunctus theogenis* (Capronnier), *Arita arita* (Schaus), *Lerema ancillaris ancillaris* (Butler), *Morys valerius valerius* (Möschler), *Morys geisa geisa* (Möschler) and a probable *Tigasis* sp. are described and illustrated, and notes are provided on the early stages of *Cobalopsis nero* (Herrich-Schäffer) and *Morys compta compta* (Butler).

Key words (not in title): Trinidad & Tobago, Tobago, life history, food plant, parasitism.

INTRODUCTION

This paper continues on from Cock (2011) dealing with the Trinidad species of the tribe Moncini of the Hesperiidae, Hesperiinae. In this section, I deal with what I have categorised as the spotted Moncini, the genera *Cymaenes*, *Cobalopsis*, *Arita*, *Lerema*, *Morys* and *Tigasis*, i.e. small brown species with variable pale spotting, which superficially are all rather similar, but on closer inspection show differences in the spots, UNH colouring and male brands which facilitate identification. All these genera were placed in Genera Group J of Evans' (1955) treatment of the subfamily Hesperiinae. As in the previous section, I have not focussed on the delineation of genera, but rather tried to provide adequate illustrations and diagnostic notes to facilitate species identification.

In this paper, all specimens illustrated are in the author's collection unless indicated otherwise. Similarly, any specimens referred to without attributing a collector or collection, were collected by the author and are in either the author's collection or the collection of CABI, Curepe, Trinidad. Other conventions and abbreviations follow earlier parts of this series (Cock 2011 and earlier papers). Plant names have been checked against Tropicos (2011) and The Plant List (2011). The museum abbreviations are given in the acknowledgements at the end of the paper.

Cymaenes Scudder 1872

This genus of 27 species (Mielke 2004) is found from USA throughout the Neotropical Region. Adults have no secondary sexual characters, and although they are superficially similar to several other genera, the genitalia indicate a distinct group (Evans 1955). Three species are found in Trinidad, one of which has not been identified and may be undescribed.

Food plants are mostly Poaceae, but Cyperaceae are also recorded (Beccaloni *et al*. 2008). Janzen and Hallwachs (2011) have reared several *Cymaenes* spp. from a variety of grasses, particularly *Paspalum* and *Setaria* spp.

J27/1 *Cymaenes tripunctus theogenis* (Capronnier 1874)

Figs. 1-5.

The nominate subspecies, *tripunctus* (Herrich-Schäffer 1865), was described from Cuba and occurs there and on Jamaica, the Cayman Islands, Hispaniola (Evans 1955), in southern Florida (Smith *et al*. 1994) and as an introduced species on New Providence Island, Bahamas (Cock 1998). The mainland subspecies, *theogenis* (Capronnier), was described from Botofogo (Rio de Janeiro, Brazil), and is found throughout the Neotropics, from Mexico to Paraguay (Evans 1955). It is characterised as slightly larger, paler and with the spots more developed (Evans 1955).

Kaye (1921, 1940) did not record this species from Trinidad, although since it occurs commonly, and there are specimens that he probably saw in the NHM, he may have misidentified it as another species. Evans' (1955) listing of seven males and 12 females from Trinidad is the first record from the island. However, Sheldon (1936) did record it from Tobago, where he found it not uncommon at Speyside.

Skinner and Williams (1923) in their work on the genitalia of the North American Hesperiidae illustrate the male genitalia of *C. tripunctus*, but since their specimen is from Suriname, it must be *C. tripunctus theogenis* that is illustrated rather than *C. tripunctus tripunctus*, the subspecies which occurs in Florida. The same drawing is used to illustrate this species in Lindsey *et al*. (1931), and appears to have been copied by Hayward (1950, plate xi.5). Cock (1985) illustrates the male genitalia of a Trinidad specimen. Comparing the two figures, it can be seen that the lateral view of the Suriname male is confused due to the right half of the uncus and gnathos being drawn in below the left half, whereas in the figure of the Trinidad specimen only the left half is shown. Furthermore, the left valve in the Trinidad figure, stated to be in ventral view, is actually the internal view, and hence a mirror image of the right valve shown in the Suriname figure.

Mielke (1989) illustrates the male genitalia of *C. tripunctus tripunctus* from Jamaica. The valves of the two subspecies appear very similar but there are minor differences in the uncus and gnathos.

UPF generally with white spots in spaces 2, 3 and 6-8; usually an upper cell spot and at least a trace of a spot in space lB, stronger UNF; diffuse pale spot space 1 B UNF. The UNH has an indistinct discal band of spots. Sexes similar, but spots usually stronger in the female, which has more rounded wings.

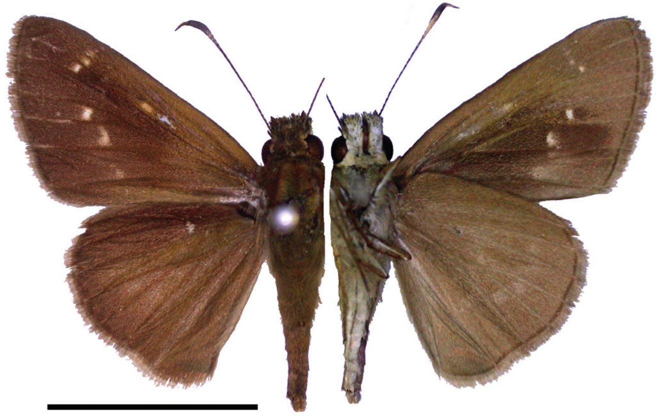

Fig. 1. Adult ♂ *Cymaenes tripunctus theogenis*, collected as caterpillar on *Megathyrsus maximus*, Mt. St. Benedict, 26.ii.1994, ref. 94/1.

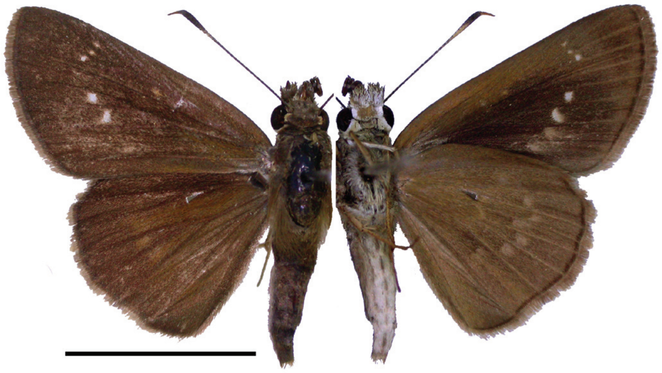

Fig. 2. Adult ♀ *Cymaenes tripunctus theogenis*, Point Gourde, 12.vii.1997.

This species is widespread and quite common (34 records) in lowland areas of Trinidad, but not extending into the higher parts of the Northern Range, and with few records from southern Trinidad. Records from Crown Point, Rockley Bay and Scarborough suggest it is also widespread in Tobago. The months of capture indicate that it flies throughout the year in both Trinidad and Tobago.

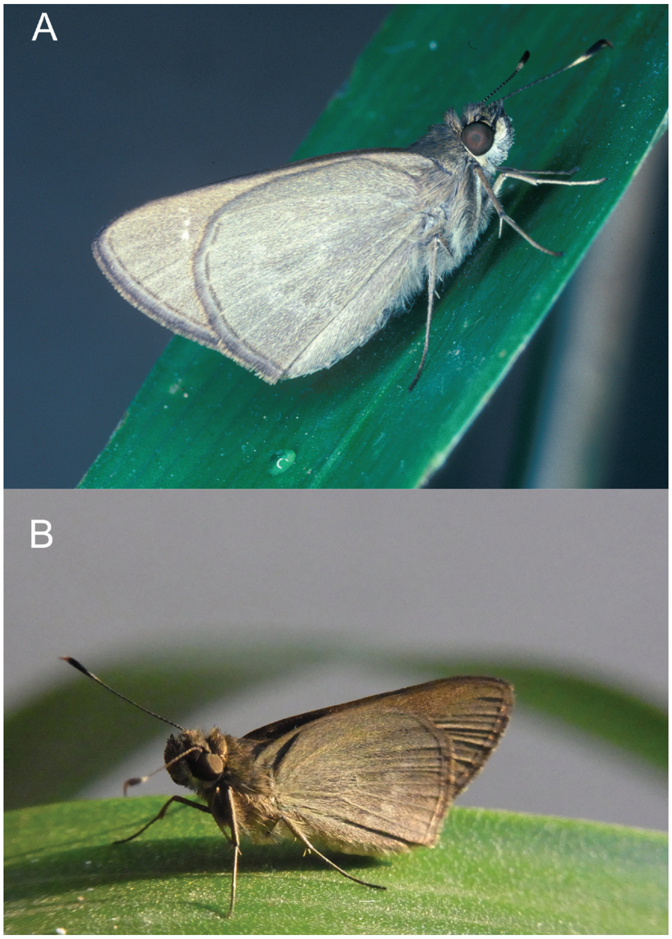

Fig. 3. Adult ♀ *Cymaenes tripunctus theogenis*.**A**, collected as caterpillar on *Megathyrsus maximus*, Mt. St. Benedict, 26.ii.1994; adult 23.iii.1994 (ref. 94/1); **B**, collected as final instar on *Setaria barbata*, Port of Spain, 18.xi.2011, adult 15.xi.2011 (ref. 11/72A). The apical spots are clearer in A, and the UNH discal band in B.

The early stages of ssp. *tripunctus* have been documented by Dethier (1939, 1942a) on grasses and sugar cane in Cuba, and by Cock (1998) on several grasses on New Providence Island, Bahamas. Comstock (1944) gives Guinea grass, i.e. *Megathyrsus maximus*, as a food plant and this record and those of Dethier (1939) have been repeated by most authors on the Caribbean and USA Hesperiidae. Minno *et al*. (2005) describe the shelters, show a colour photograph of the caterpillar and add grass food plant records from *Digitaria ciliaris*, *Paspalum setaceum*, *Tripsacum dactyloides*, and *Brachiaria mutica* (=*Urochloa mutica*). Bamboo has been reported as a food plant in Cuba (Bruner *et al*. 1975, as listed by Beccaloni *et al*. 2008).

Dethier's (1942b) study on the structure of the wax glands of Hesperiinae included caterpillars of *C. tripunctus*. He refers to these glands occurring on the subventral area of A7-A8, so presumably that is the case for this species, although observations from other Hesperiinae have shown different arrangements (Cock 2001, 2003, 2005, 2006, 2009, 2010).

Subspecies *theogenis* has been reported from various grasses, including sugar cane (*Saccharum officinarum*) and other grasses in Argentina (Pastrana 2004). In Trinidad, I have reared this species on *Paspalum virgatum* (Macoya Gardens, 39C), three times on *Megathyrsus maximus* (Point Gourde ref. 94/4, Mt. St. Benedict refs. 94/1 and 03/200) and twice on *Setaria barbata* (Mt. St. Benedict ref. 94/59A, Port of Spain ref. 11/72) (Cock 1998; Beccaloni *et al*. 2008).

A penultimate instar caterpillar collected on *M. maximus* (ref. 94/1) had formed a shelter from a large leaf, with the distal 19 cm pendulous from where the caterpillar had eaten to the midrib from both sides; the distal part of the leaf was rolled; shelter sealed at the basal end with a flap; more feeding distal to the shelter and at apex of leaf. A final instar caterpillar collected on *Setaria barbata* (ref. 94/59A) was in a shelter which at the time I considered to be identical to that of *Lerema ancillaris* (Butler) on ?*M. maximus*, collected the day before (ref. 95/58) and described below under *L. ancillaris*.

The last two instar caterpillars are similar; the final instar grows to about 25 mm. They are quite variable in the detail and extent of the head markings (Fig. 4). Individual 03/200 is described here. Head widest near base, slightly indent at vertex; a strong black line from vertex laterally to mouthparts; posterior to black line is translucent green; the face ground colour off white; a strong black line down epicranial suture, diffuse externally; frons translucent green with narrow vertical line down middle; on each epicranium, a diffuse dark arc from upper epicranium converging towards epicranial suture, and running lateral to adfrontal sutures, diverging level with the base of the frons and running to the stemmata. T1 concolorous with body. Body translucent green; a clear, darker dorsal line, bordered by a broad yellow-green subdorsal line; two whitish dorsolateral lines, the upper one T2-A9, and the lower T3-A7; a pale ventrolateral line below spiracles A1-A9; spiracles pale, inconspicuous; all legs concolorous; anal plate semicircular. The final instar lasted 20 days for the only caterpillar reared from the penultimate instar (ref. 94/4).

Individual 94/1 had the frons brown, bordered with black, and the diffuse arc in epicranium was a diffuse vertical line. Individual 94/4 (Fig. 4C) had the vertex and dorsal part of the epicranial suture reddish brown; frontal and adfrontal sutures dark; the diffuse line on each epicranium, roughly vertical, as the last; T1 with a very narrow, dark, dorsal plate. Individual 11/72A (Fig. 4D) was similar to the last, but with dark brown dorsal markings instead of reddish brown.

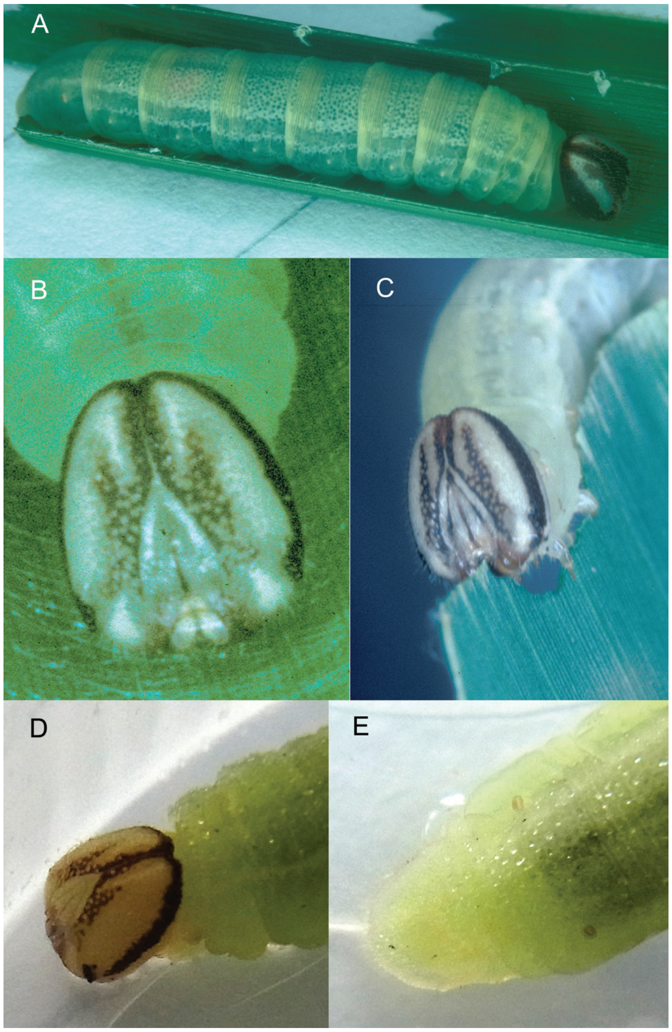

Fig. 4. Final instar caterpillar of *Cymaenes tripunctus theogenis*. **A**, dorsolateral view, collected as caterpillar on large coarse grass, Rio Claro-Guayaguayare Road, 11.x.1993, pupated 15.x, photo 11.x (ref. 93/9); **B**, detail of head, collected as final instar caterpillar on ?*Megathyrsus maximus*, Mt. St. Benedict, 21.iii.2003, pupated 26.iii, photo 21.iii (ref. 03/200); **C**, detail of head, collected as penultimate instar caterpillar on *M. maximus*, Point Gourde, 26.ii.1994, moulted 27.ii, pupated 17.iii, photo 8.iii (ref. 94/4); **D**, detail of head, collected as final instar on *Setaria barbata*, Port of Spain, 18.xi.2011, pupated 29.x, photo 24.x (ref. 11/72A); **E**, detail of anal plate, as D.

At the prepupal stage, individual 94/59A had subventral wax glands on the posterior part of A6, on A7, and the anterior part of A8; while individual 11/72A had subventral glands from the edge of the posterior margin of A6 to the anterior half of A8, whereas individual 94/4 was noted to have a single solid mass subventrally on A7-A8. More observations on the wax glands would be desirable to clarify whether they are variable in position and extent, change over time, or differ between sexes (or caterpillar 94/4 was incorrectly recorded).

Pupation is in a simple leaf roll held by several strands of silk; the cremaster is attached to a crossbar of silk, and there is a simple thoracic girdle. In spite of the well developed wax glands observed in prepupae, there was no white waxy powder on the pupa or lining the shelter in the case of individual 03/200 (Fig. 5). The pupa measured 20-22 mm; green; 2 mm frontal spike; whitish subdorsal and dorsolateral lines on abdomen (ref. 03/200). Pupation lasted 11-17 days.

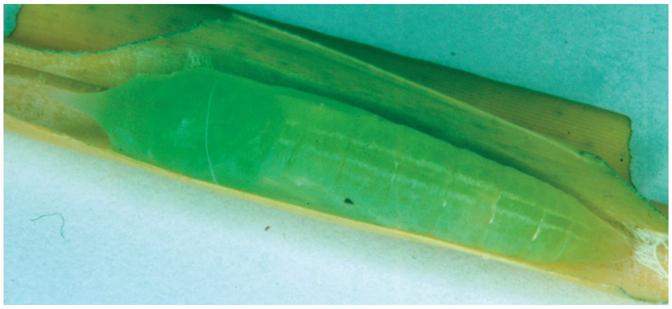

Fig. 5. Pupa of *Cymaenes tripunctus theogenis,* collected as caterpillar on large coarse grass, Rio Claro-Guayaguayare Road, 11.x.1993, pupated 15.x, photo 16.x (ref. 93/9).

As noted previously (Cock 1998), given that the caterpillars of both subspecies of *C. tripunctus* are variable, they cannot be separated in the early stages.

One of two caterpillars collected together in Port of Spain on *Setaria barbata,* 18.xi.2011 (ref. 11/72B) was parasitized (the other caterpillar was successfully reared and I am assuming they were both *C. tripunctus*). Three days after collection, a braconid larva emerged from a penultimate instar caterpillar, and spun a fluffy white cocoon in the host shelter; the adult wasp emerged 11 days later. The cocoon and adult were similar to those of *Fornicia* spp., but it has not been identified.

J27 *Cymaenes finca* Cock 1985

Figs. 6-7.

This species was described from Trinidad (Cock 1985), and as yet it has not been recorded from elsewhere. Although not stated in the original description, the specific name is a noun in apposition, and is a pun on the type locality, Spanish Farm (*finca* being the Spanish for farm). The type series is split between the collections of the NHM, USNM and the author.

Cock (1985) illustrates the male genitalia and compares them with those of *C. tripunctus theogenis*. The male has a weak spot in space 1B, and spots in spaces 2, 3 and 6, whereas the female has spots in 1B, 2, 3 and 6-8. UNF at most a hint of a spot in space 1B; similarly a hint of a discal band UNH. This species is similar to *C. tripunctus*, but larger and with different genitalia (Cock 1985).

Fig. 6. ♂ *Cymaenes finca*, Las Lomas, Spanish Farm, 17.xii.1980, M.J.W. Cock (holotype in NHM).

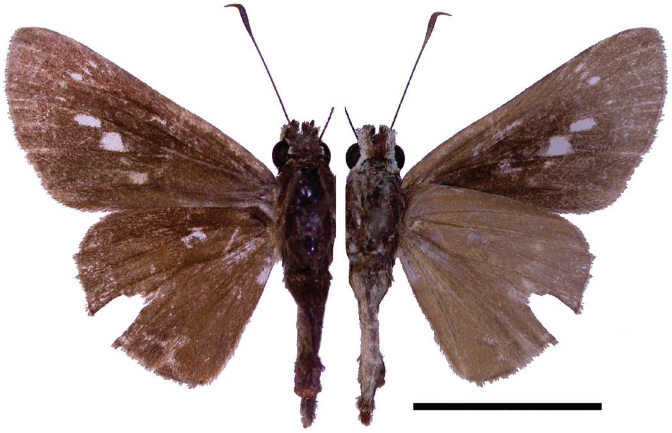

Fig. 7. ♀ *Cymaenes finca*, Las Lomas, Spanish Farm, 2.viii.1980, M.J.W. Cock (paratype in NHM).

The type series of eight males and one female was taken at Spanish Farm, Las Lomas, between March 1980 and August 1981, three of the males being captured at dusk on two separate occasions. Since then, I have caught a further two males at Arena Forest Reserve, 2.x.1982. I am not aware of any other captures. This seems to be a localised species associated with lowland forest. I was collecting at Spanish Farm at dusk, hoping to catch *Pachythone erebia* Bates (Riodinidae). This is the species known from Trinidad as its synonym, *P. barcanti* Tite, which was described from this locality from specimens caught at dusk by Malcolm Barcant (Tite 1968; Barcant 1970). Since collectors rarely search for small brown-black butterflies at dusk, it is difficult to know how significant these early evening captures of *C. finca* are, or how widespread either species might be if other areas of lowland forest were checked at this time of day.

The early stages and food plants are unknown, but this is likely to be another grass-feeding species.

J27 *Cymaenes* sp. nr. *campestris* Mielke 1980

Figs. 8-9.

This record is based on a single male specimen collected by Sir Norman Lamont at Morne Diablo, 10.xi.1929 (Figs. 8-9), which Kaye (1940, no. 381E) recorded incorrectly from Trinidad as *Lerodea fusca* (Grote and Robinson), although the species actually intended was *L. eufala eufala* Edwards (Cock 2004). I examined Lamont's specimen in the NMS, and concluded that it is a species of *Cymaenes* close to or the same as *C. campestris* Mielke described from Paraná, Santa Catarina and Rio Grande do Sul, Brazil (Cock 2004). However, examination of a male paratype of *C. campestris* in the NHM, suggests that this Trinidad specimen is not conspecific. The large gap between southern Brazil and Trinidad also suggests the Trinidad specimen is unlikely to be conspecific, so it probably represents an undescribed species.

Fig. 8. ♂ *Cymaenes* sp. nr. *campestris*, Morne Diablo, 10.xi.1929, N. Lamont (specimen in NMS). Note the dark shading on the costa UNH is an artefact due to the positioning of the camera flash; the UNH is more or less uniformly coloured.

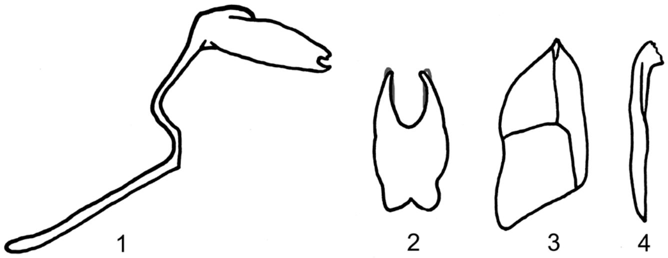

Fig. 9. Genitalia of ♂ *Cymaenes* sp. nr. *campestris*, Morne Diablo, 10.xi.1929, N. Lamont (specimen in NMS). **1**, lateral view without claspers and penis; **2**, uncus and gnathos dorsal view; **3**, left valve, internal view; **4**, left valve ventral view.

There is no new information on this species, and the life history and food plants are unknown. I am reluctant to describe this as a new species based on a single specimen, so I encourage collectors in Trinidad to keep an eye out for more.

Cobalopsis Godman 1900 in Godman 1899-1901

Godman (1900) established this genus with *edda* (Mabille) as its type species. However, *edda* is now considered a synonym of *C. autumna* (Plötz), a species which is not known to occur in Trinidad. Although Kaye (1904) included *C. edda* in his first list of butterflies "a single specimen only in June 1898 (W.J. Kaye)", he did not include it in subsequent lists, so he probably concluded that this was a misidentification.

There are no secondary sexual characteristics in this genus (Evans 1955). The reported food plants are Poaceae (Beccaloni *et al*. 2008).

J37/4 *Cobalopsis nero* (Herrich-Schäffer 1869) in Herrich-Schäffer 1867-71

Figs. 10-11.

Herrich-Schäffer (1867-71) briefly described this species based on a female specimen without locality, but the description is not diagnostic and no subsequent authors seem to have referred to the type. O.H.H. Mielke (pers. comm. 2011) sent me a picture of a type from Berlin which appears to be a male without abdomen, the markings of which are close to that shown here (Fig. 10), but the white hyaline spots F are slightly larger. However, both UNH of the type seem to have lost most of their scales and the spots in spaces 2-4 UNH that Herrich-Schäffer refers to (and can be seen in Figs. 10-11) are not visible. Evans (1955) defined his use of *nero* by including several synonyms, including *dyscritus* (Mabille) (♂ type from Colombia), for which Godman (1900, plate 98.33) and Hayward (1950, plate viii.1) illustrated the male genitalia. *Cobalopsis nero* occurs from Mexico to Paraguay, but based on the numbers in the NHM has been collected most often in northern South America, including Trinidad (Evans 1955).

Kaye (1940, no. 397A) introduced this species to the Trinidad catalogue as *Cobalopsis lucifer* (Hübner), giving *dyscritus* as a synonym and listing a specimen from Maupertuis, 16.ii.1922 (Sir N. Lamont). Evans (1955) and Mielke (2004) place *lucifer* in the genus *Decinea*. However, given that *dyscritus* is now treated as a synonym of *Cobalopsis nero*, and that there is a Lamont specimen of *C. nero* with this data in the NMS, I have made the reasonable assumption that Kaye's record of *lucifer* is a misidentification for the species now known as *C. nero* (Cock 1982).

UPF with spots in spaces 1B (sometimes in male, stronger in female), 2, 3, 6-8 and upper cell; UNF diffuse spot in space 1B; UNH paler brown with a weak purple flush and variably pale spots in spaces 2-5.

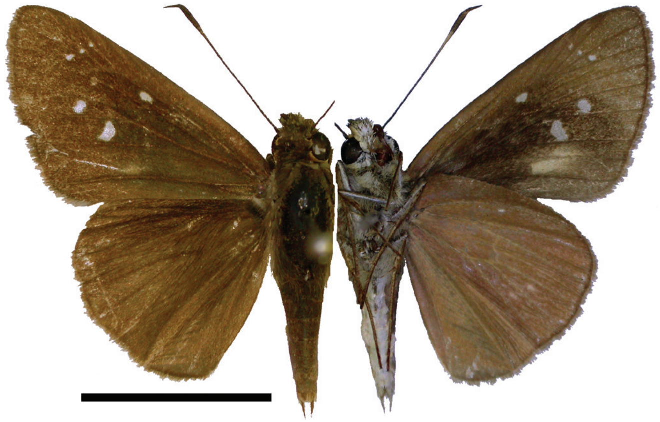

Fig. 10. ♂ *Cobalopsis nero*, Las Lomas, Spanish Farm, 17.xii.1980.

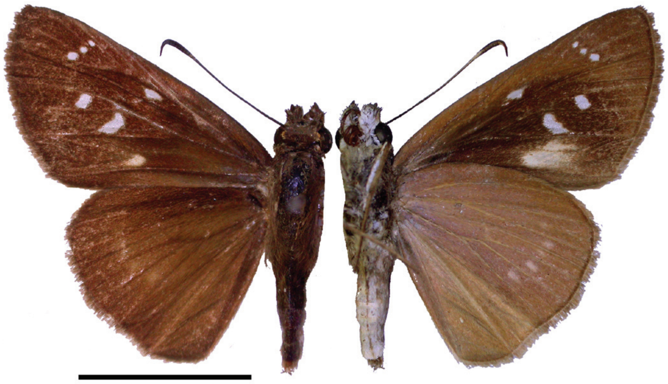

Fig. 11. ♀ *Cobalopsis nero*, Parrylands, 3.iii.1980.

There are two emerged pupae and a final instar head capsule in the NHM dry early stages collection as *Cobalopsis nero*. However, the pupae are too large to be *C. nero* and Moss actually labelled them as *Prenes nero*, i.e. *Panoquina nero* (Fabricius), a Caribbean species, and they do resemble those of *Panoquina* spp. (Cock 2001).

The 41 Trinidad records that I am aware of show this species to be widespread in lower areas of northern and central Trinidad, but with only one record from the south (Parrylands, 3.iii.1980). Only 14 records include the exact month of capture, and these show that most captures are between December and April, i.e. during the dry season.

Hayward (1969) gives *Saccharum officinarum* as a food plant in Argentina. Pastrana (2004), quoting Hayward (1969), gives this as sugar cane and other grasses. Janzen and Hallwachs (2011) have reared this species frequently from *Megathyrsus maximus*, *Paspalum virgatum*, *Setaria palmifolia* (=*S. paniculifera*) and *S. poiretiana*, and occasionally from several other grasses.

My unpublished food plant record of bamboo for *C. nero* in Beccaloni *et al*. (2008) is an error that I made when reference numbers on two specimens from Curepe were transposed (Cock 2009). Hence the record for *C. nero* (ref. 81/41) is actually from an unidentified broad-leaved grass. Fortunately, my notes and the associated larval and pupal remains with the two specimens leave no room for doubt as to the correct association.

My record is based on a single collection made at Curepe, 28.xii.1981, in secondary forest. The shelter was a leaf roll at the base of a leaf. The head was slightly indent at vertex; dark with pale adfrontals and a pale inverted U in dorsal half of epicranium, the lateral arm extending diffusely to stemmata, which are in a pale patch. T1 concolorous with body. Body slightly opaque, with a clear dorsal line bordered with pale area; yellow tint to posterior of each segment; faint pale lateral line along trachea; pale ventrolateral ridge; spiracle A8 dark, other spiracles pale. The pupa measured 27 mm; elongate; pale green; frontal spike stout, 3 mm; proboscis extends almost to base of cremaster. A female emerged after nine days.

J37/6 *Cobalopsis miaba* (Schaus 1902)

Figs. 12-13.

For many years this species has been known as *Cobalopsis potaro* (Williams and Bell 1931), (Evans 1955; Cock 1982). However, Mielke (1980) studied the type of *Megistias miaba* Schaus (1902) and established that it is a senior synonym of *Cobalopsis potaro*. *Papias elegans* Hayward, described from Ecuador, is also a synonym (Evans 1955; Mielke 2004). *Cobalopsis miaba* is found from Costa Rica to Paraguay, but more than half the specimens in the NHM are from Trinidad and Guyana (Evans 1955).

Fig. 12. ♂ *Cobalopsis miaba*, Mt. Tabor summit, 1850 ft. (564 m), 5.viii.1979.

Fig. 13. ♀ *Cobalopsis miaba*, El Tucuche, 2600 ft. (790 m), 11.viii.1979.

The male genitalia are illustrated by Williams and Bell (1931, Fig. 29, as *Euroto potaro*) and Hayward (1940, Fig. 17, as *Papias elegans*).

In the male, the UPF spots in spaces 2 (often indistinct in male), 3 and 6-8 (7-8 may be indistinct or absent in males) are small; no spots in spaces 1B or cell; diffuse white area in space 1B UNF. The UNH is dark brown with a reddish purple sheen; small pale spots in spaces 1C-7. Female similar but F spots stronger and wings more rounded.

Based on the 64 records that I have of this species from Trinidad, it seems to be a common species in the Northern and Central Ranges, with only occasional records from lowland areas, e.g. Point Gourde (17.i.1988) and Las Lomas, Spanish Farm (17.xii.1980), and no records from the south of the island. Most records are from the higher parts of the Northern Range that have been collected, i.e. from Morne Catherine to Morne Bleu. Records extend in the Northern Range to the summit ridge of El Tucuche (9.i.1980) and in the Central Range to the summit ridge of Mt. Tamana (common, 13.vii.1997). On three occasions I have taken pairs *in copulo*, an unusually high proportion of captures (almost 10%). The months of capture of 47 specimens are throughout the year, except May-June, with peaks in January and July-August.

Steinhauser (1975) reports a single female specimen provisionally identified as *C. miaba* (=*C. potaro*) reared from "long grass" by Miguel and Francisco Serrano in El Salvador. I have found no other information on the life history and food plants.

Arita Evans 1955

This is a genus of four species (Mielke 2004), of which one, the type species *arita* (Schaus), is found in Trinidad. The genus has no secondary sexual characteristics.

J38/1 *Arita arita* (Schaus 1902)

Figs. 14-18.

Schaus (1902) described this species from Trinidad as *Cobalus arita*, and Evans (1955) placed it in his new genus *Arita*. Evans (1955) reported specimens from Colombia to south Brazil, and it is also present in Panama (Lindsey 1925) and perhaps further north in Central America, e.g. Costa Rica (Janzen and Hallwachs 2011) and Mexico (based on *Thoon wellingi* Freeman, a possible synonym – see below).

Kaye (1914) described *musa* on the basis of specimens from "Emperor Valley, Jan. 29, 1913 (K. St. A. Rogers); in coll. Kaye from St. Ann's Valley (G. E. Tryhane)". Implicitly this is two specimens, and I have traced two specimens recognised as types which match. The K. St. A. Rogers specimen is in HEC; it is a female and a good match to the illustration in Kaye (1914, pl. 30.6). The other is in MGCL from the W.J. Kaye collection; it is a male *A. arita* which has been dissected and identified by S.R. Steinhauser (A.D. Warren, pers. comm. 2011). No further information is added in Kaye (1921). Evans (1955) may have seen either of these types, but refers to a female type from Trinidad in the NHM. There is a holotype label adjacent to a female from Caparo in the NHM, but this cannot be a type. Evans (1955) made

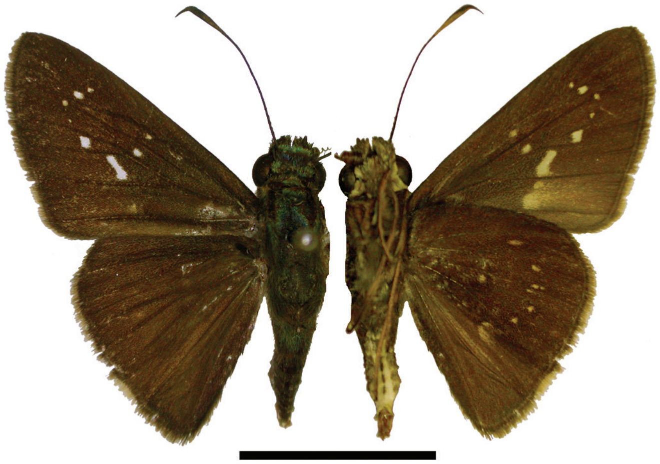

Fig. 14. ♂ *Arita arita*, Mt. Tamana, c. 250 m, 12.xi.1995.

Fig. 15. ♀ *Arita arita*, San Miguel Valley, old cacao estate, 17.x.1979.

musa a synonym of *A. arita*. Kaye (1940, no. 396B) also noted *A. arita* as a Trinidad species commenting, "I have not seen this species".

Lindsey (1925, plate 30.5) illustrates the male genitalia (as *Cobalus arita*) – either from Panama or Guyana. Bell (1942) described *Tigasis akuris* Bell from Venezuela and illustrated the male genitalia, which Mielke and Casagrande (2002) found to be a synonym of *A. arita*.

Freeman (1969) described *Thoon wellingi* from Mexico and illustrated the female and male genitalia (Freeman 1969, Fig. 17). This species is now treated as a synonym of *A. arita* (Mielke 2004). However, although Freeman's illustration of the male genitalia does suggest an *Arita* sp., it is not a close match to those of *A. arita* illustrated by Lindsey (1925) and Bell (1942), so this synonymy may need to be reconsidered.

The male has UPF spots in spaces 1B (a trace or absent), 2, 3, (rarely in 4 and 5), 6 and 7, upper cell and usually lower cell; the spot in space 2 is narrow and oblique – a useful character to recognise this species, in common with *Tigasis garima* (Schaus) below. UNH reddish brown with a purple sheen; spots in spaces 1C-7, cell and a blurred spot in space 1B adjacent to that in space 1C. The female is similar but the F spots are more pronounced, especially that in space 2, and the wings are more rounded.

Fig. 16. Female *Arita arita* caught by spider, Palo Seco Oilfield, 7.xi.1995.

I have records of no less than 74 specimens of *A. arita* from Trinidad, 47 males and 27 females. It is found in forested areas throughout the island from lowlands to about 2,000 ft. (610 m). Captures are in forest, along roadsides and tracks, and sometimes at eupatorium flowers at forest edges. Bacon *et al*. (1974) recorded it as *Cococilopsis* [sic] *musa* (=*Cobalopsis musa*) from Nariva Swamp, which Cock (1981) corrected to *A. arita*.

Janzen and Hallwachs (2011) have reared this species repeatedly from *Olyra latifolia* and another unidentified grass. Beccaloni *et al*. (2008) quote Cock (pers. comm. 1997) that the food plant of *A. arita* in Trinidad is *O. latifolia*.

My single rearing record was from a final instar caterpillar collected 6.v.1995 on *O. latifolia* on Lalaja Ridge (ref. 95/17). It was found in a 35 mm shelter cut from one edge of the leaf lamina and folded upwards, with feeding basal to the shelter. The caterpillar (Fig. 17) measured 26 mm; head slightly indent at vertex; light brown, adfrontal sutures dark, extending diffusely onto epicranium; stemmata black. Body pale, dull, translucent green with the dorsal line darker; T1 and all legs concolorous with body; spiracles pale, inconspicuous; gonads yellowish. Wax glands developed before pupation, but I did not record details.

The pupa (Fig. 18) measured 17 mm; smoothly rounded; flattened anteriorly due to bulbous eyes; abdomen fairly elongate; proboscis extends 3½ segments beyond wing cases; head, thorax and appendages brown;

Fig. 17. Anterolateral view of head of instar 5 caterpillar of *Arita arita,* collected 6.v.1995 on *Olyra latifolia*, Lalaja Ridge, photo 6.v.1995, 26 mm, ref. 95/17.

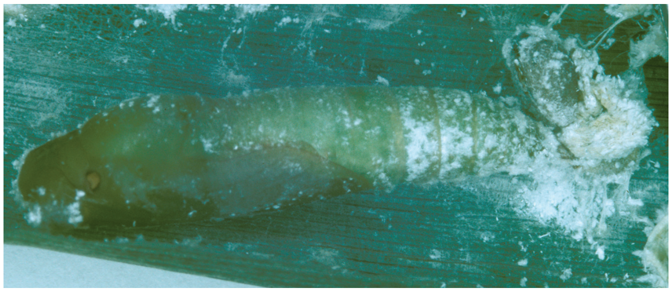

Fig. 18. Dorsolateral view of pupa of *Arita arita,* collected as caterpillar 6.v.1995 on *Olyra latifolia*, Lalaja Ridge, pupated 16-19.v., adult 7.vi., photo 21.v., 17 mm, ref. 95/17.

abdomen pale green-brown with trace of dorsal line; spiracle T1 dark matt brown. White waxy powder on eyes and posterior half of abdomen; shelter lined with light covering of white waxy powder, with heavier deposits at each end.

Lerema Scudder 1872

Lerema accius (J.E. Smith) from the USA is the type species of this genus of eight species, which is found throughout the Neotropical Region. There are many records of *L. accius* as a grass-feeder (Beccaloni *et al*. 2008), as well as one from *Wisteria* (Fabaceae) (Hayward 1947) which needs confirmation before it can be accepted. Males of this genus have a compact, broad, tripartite stigma from base of vein 3 to vein 1 UPF.

J39/3 *Lerema ancillaris ancillaris* (Butler 1877)

Figs. 19-26.

Butler (1877) described *L. ancillaris* based on a male from "Amazons", Brazil. The nominate subspecies is found from there north to Panama, while subsp. *liris* Evans 1955 is found in Central America. Subspecies *liris* has slightly different genitalia (Evans 1955) and some authors have treated it as a valid species, but not Mielke (2004) in the checklist of Neotropical Lepidoptera.

The male genitalia of ssp. *ancillaris* have been illustrated from Guyana by Lindsey (1925, plate 30.9 as *L. mooreana* Dyar, a synonym) and Hayward (1950, plate ix.5); Scott (1986, Fig. 71.449) illustrates the valve.

Kaye (1921, 1940) did not record this species from Trinidad, but given that it is a common species, and Lamont collected specimens (Palmiste: ♀ 18.iv.1926 [N. Lamont] [NMS]; ♀ 13.iii.1932 [N. Lamont] [NMS]), Kaye may have misidentified material (cf. *Cymaenes tripunctus theogenis* above). In contrast, Sheldon (1938) probably recorded it twice from Tobago as *Lerodea phocylides* (Plötz) from Roxborough (F. d'A[abadie]), and *Lerema parumpunctata* (Herrich-Schäffer) from Scarborough, one specimen (W. G. S[heldon]), both of which are synonyms of the rather similar *Lerema accius* found from Central America to Venezuela, but not known from Trinidad. Barcant (1970) listed the second of these as *L. parum punctata* from Tobago (Cock 1982).

Males usually have spots in spaces 2 (sometimes absent), 3 and 6-8 (Fig. 19), although some have no spots apart from mere traces of the spots in spaces 6-8 UPF and UNF (Fig. 20); UNF no spot in space 1B; UNH indistinct spots in spaces 1C-3. The female is more heavily spotted, with UPF spots in spaces 1B, 2, 3, 6-8 (Figs. 21-22); some may have both upper and lower spots in space 1B as well as an upper cell spot (Fig. 22); UNH variable spots in spaces 1C-7 (Fig. 22), often indistinct (Fig. 21).

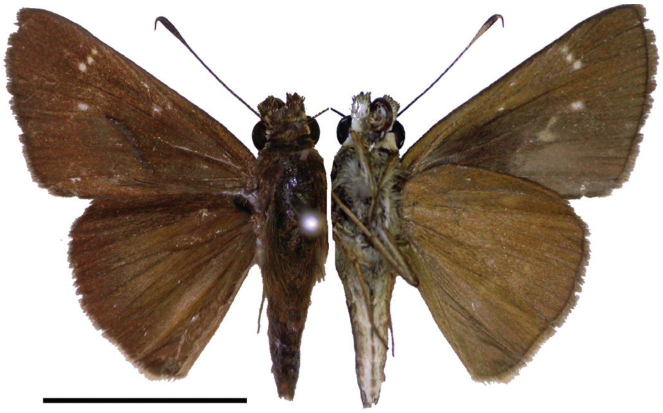

Fig. 19. ♂ *Lerema ancillaris ancillaris*, Point Gourde, 12.vii.1997.

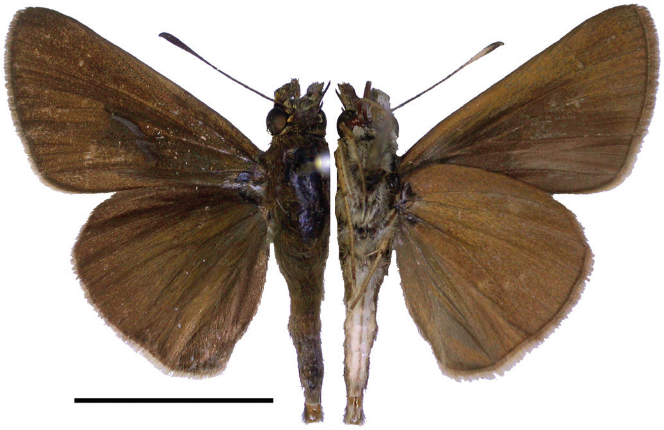

Fig. 20. ♂ *Lerema ancillaris ancillaris* with reduced spotting F, Point Gourde, 12.vii.1997.

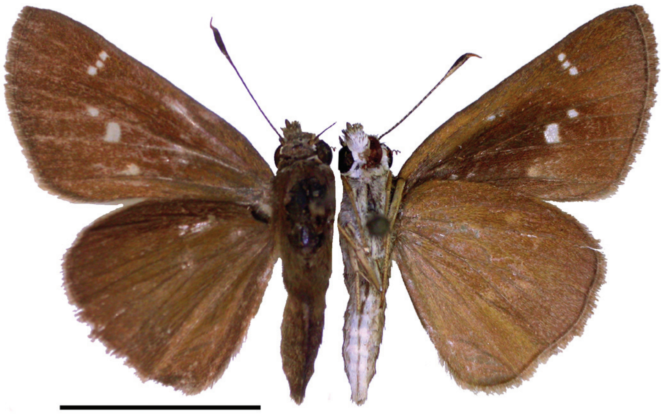

Fig. 21. ♀ *Lerema ancillaris ancillaris*, Caroni Swamp, ¼ mile east of Cacandee Sluice, 20.ii.1982.

I have records of 27 specimens captured in Trinidad: 17♂♂ and 10♀♀. These show that *L. a. ancillaris* is widespread in lowland, disturbed situations throughout the island, and it extends into forested areas along roadsides, but doesn't occur in forests. There are several captures from swampy areas, including Caroni Swamp (Cacandee Sluice), Nariva Swamp (Manzanilla-Mayaro

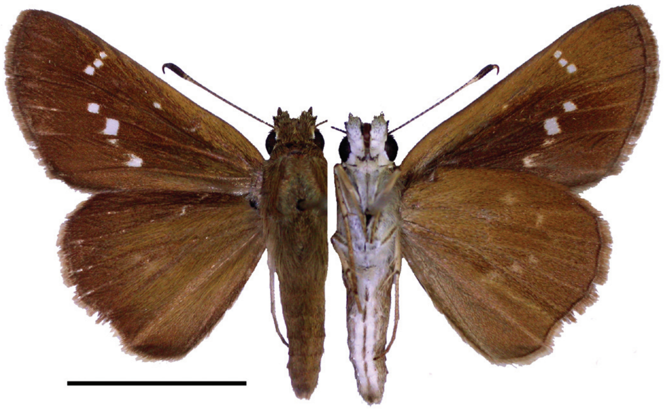

Fig. 22. ♀ *Lerema ancillaris ancillaris*, collected as pupa on *Setaria poiretiana*, Curepe, 25.x.1981, ref. 7B.

Road (Cock 1981) and Sand Hill), and Oropouche South Lagoon, but it is not clear whether these represent disturbed areas adjacent to swamps or a genuine association with swamps. The months of capture do not show a clear pattern; although most specimens have been caught in the dry season (February-April) or July, the former is linked with collecting at the edge of swamps, when these areas are more accessible, and the latter reflects a single occasion when this species was common at Point Gourde in 1997.

Both subspecies feed as caterpillars on a variety of grasses. Moss (1949) reared subspecies *ancillaris* from "ribbon" or "fan" grasses at Belem (Para) Brazil, which may (or may not) refer to *Phalaris arundinacea*, as listed by Beccaloni *et al*. (2008) on the basis of Moss' record. Dyar (1914) described the synonym *L. mooreana* Dyar from Guyana, reared from larvae on sugar cane by H.W.B. Moore. Hayward (1950) gives *Saccharum giganteum* (=*Erianthus saccharoides*), *S. alopecuroides* (=*E. alopecuroides*), *S. poiretianum* (=*Panicum poiretianum*) and other grasses as food plants, as well as *Wisteria speciosa* (Fabaceae) – an unlikely record that needs confirmation. Subsequent authors have repeated some of these records (e.g. Hall 1939; Hayward 1947; Pastrana 2004; Beccaloni *et al*. 2008). Cock (pers. comm. 1997 in Beccaloni *et al*. 2008) listed ?*Megathyrsus maximus* (=?*Panicum maximum*) and *Setaria poiretiana* as food plants in Trinidad. In the NHM there are specimens reared by H.E. Box from sugar cane in Trinidad (ix.1952) and Guyana (iii.1924, species XIII) and *Paspalum* (viii.1923, ref. 65).

Fig. 23. Adult female of *Lerema ancillaris ancillaris*, collected as caterpillar on ?*Megathyrsus maximus*, Port of Spain, 4.x.1994, photo 19.x.1994, ref. 94/58.

Kendall and McGuire (1975) record ssp. *liris* from a 'broad-bladed grass', *Bambusa vulgaris* and *Saccharum officinarum*, in Mexico. It has since been reared in moderate numbers from more than 25 different species of grass in Costa Rica (Janzen and Hallwachs 2011).

Hayward (1950) quotes a brief description of the caterpillar and pupa by Jørgensen (1935), which is compatible with mine below.

In addition to my rearing records (Beccaloni *et al*. 2008) of a pupa on *Setaria poiretiana* (Curepe, 25.x.1981, ref. 81/7B) and a caterpillar on ?*M. maximus* (Port of Spain, 4.x.1994, ref. 94/58), I have reared this species from a pupa on cauliflower (Aranguez Gardens, 20.vii.1980) and a caterpillar on maize (Macoya Gardens, 20.ix.1978). The pupa on cauliflower showed no signs of associated feeding, and this plant was only used as an unusual pupation site. In contrast, the pupa on *S. poiretiana* formed a shelter similar to that of the caterpillar on ?*M. maximus*, with associated feeding.

The following description is based on a final instar caterpillar found on ?*M. maximus* (ref. 94/58). A more recently collected caterpillar (ref. 11/02) was similar in the final instar (Fig. 25), but had a black head in earlier instars. The shelter (ref. 94/58) was formed in the terminal section of a leaf of about 30 cm; the edges were rolled downwards and held with silk, lamina edge to lamina edge; lightly lined with silk over the midrib; basal to the shelter, the lamina had been eaten to the midrib from both sides, and as a result the distal shelter was pendulous. The caterpillar resembled that of *C. tripunctus theogenis* (Fig. 4); 25 mm; head rounded, widest nearest ventral part, slightly indent at vertex; posterior margin narrowly dark; dark stripe from vertex laterally to mouthparts; similar stripe from vertex to frons, and weakly down frons to mouthparts; adfrontal sutures dark; epicrania white with a dark stripe down middle of front of each from below level of vertex to level with bottom of frons; area between these lines, including frons, with green tint. T1 with a very narrow, dark dorsal plate on posterior margin. Body dull pale yellow-green; dorsal line less yellow; white dorsolateral line; spiracles pale, inconspicuous; all legs concolorous with body. The prepupa developed wax glands subventrally on posterior margin of A6 and A7, and anterior margin of A8.

Fig. 24. Penultimate instar caterpillar of *Lerema ancillaris ancillaris*, collected as small caterpillar on *Megathyrsus maximus*, Mt. St. Benedict, 8.x.2011, moulted to penultimate instar 13.x, photo 17.x., moulted to final instar 22.x; 13 mm, ref. 11/02.

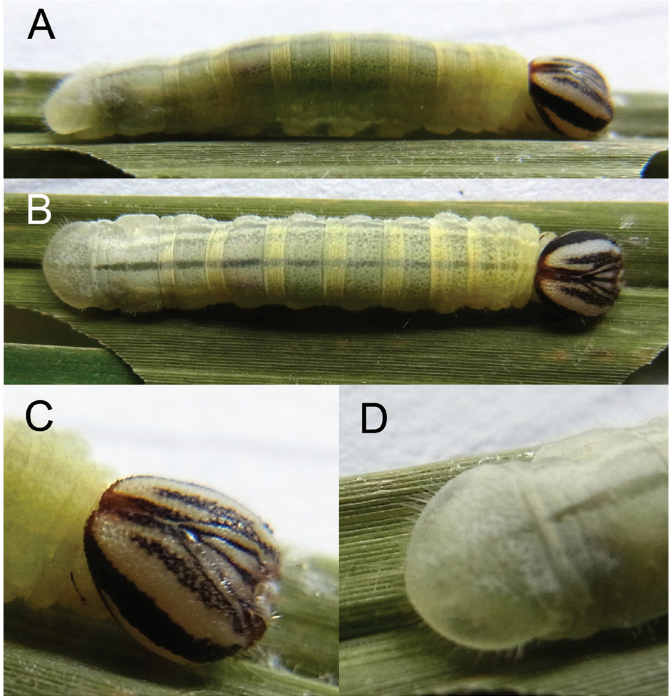

Fig. 25. Final instar caterpillar of *Lerema ancillaris ancillaris*, collected as small caterpillar on *Megathyrsus maximus*, Mt. St. Benedict, 8.x.2011, moulted to final instar 22.x, photo 24.x., pupated 7.xi; 17 mm, ref. 11/02. **A**, lateral view; **B**, dorsal view; **C**, anterolateral view of head; **D**, posterodorsolateral view of anal plate.

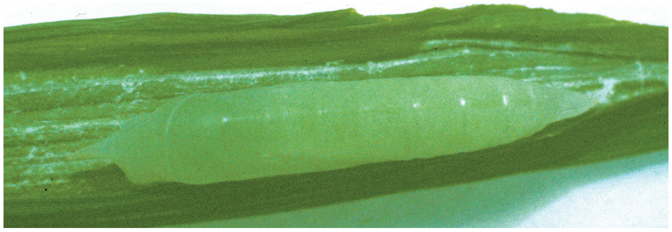

Fig. 26. Pupa of *Lerema ancillaris ancillaris*, collected on *Setaria poiretiana*, Curepe, 25.x.1981, ref. 81/7B.

The pupal chamber contained white waxy powder, but its deposition on the pupa and shelter walls was not recorded. The pupa (refs. 81/7B and 94/58) was elongate, with a well developed forward-directed frontal spike and the proboscis sheath reaching the cremaster; pale milky green; unmarked. It was held in the shelter with a simple silk girdle. Pupation lasted about 9 days.

J39/4 *Lerema lineosa* (Herrich-Schäffer 1865)

Fig. 27.

This species was described from Brazil by Herrich-Schäffer (1865) as part of the description of *Euphyes singularis* (Herrich-Schäffer) in his work on Cuban butterflies. No types have been located (O.H.H. Mielke, pers. comm. 2011), and my interpretation of the name is based on Evans' (1955) treatment. Evans lists just a few specimens from Colombia to Brazil. The only illustration of the male genitalia seems to be Evans' (1955) diagram (Mielke 2005). The only Trinidad records are those in Cock (1982).

The male has no F spots and may resemble some male *L. ancillaris* in this regard, but *L. ancillaris* always has at least a trace of these spots. The brand is shorter, thicker and darker than that of *L. ancillaris*. The female is similar to that of *L. ancillaris*, but lacks the apical spots UPF and UNF.

Fig. 27. ♂ *Lerema lineosa*, Caroni Swamp, ¼ mile east of Cacandee Sluice, 20.ii.1982.

I have only found this species near Cacandee Sluice at the edge of Caroni Swamp: 2♂ ¼ mile E of the Sluice, 20.ii.1982; and 1♂ ¾-1 mile SSW of the Sluice, 12.iv.1982 (Cock 1982). The two females of *L. lineosa* that I reported from the first locality in Cock (1982) were misidentified and are actually *L. ancillaris*. Both *Lerema* spp. were present on these occasions, either or both were feeding at flowers of *Stachytarpheta jamaicensis*, but at the time I did not distinguish between the two species. Pending further captures, it seems possible that this species may be associated with freshwater swamp in Trinidad.

Beccaloni *et al.* (2008) include no food plant records for this species, but there is a specimen in the NHM reared on sugar cane in Guyana by H.E. Box (ix.1923), but with no associated remains of the early stages.

Morys Godman 1900 in Godman 1899-1901

This genus of eight species (Mielke 2004) was established with *valerius* (Möschler) as the type species. *Euroto* Godman (type species *compta* Butler) is a synonym (Evans 1955; Mielke 2004) which appears in the Trinidad literature. Members of this genus are similar to *Lerema* spp., but differ in the form of the secondary sexual characters: instead of having a compact broad stigma, there are brands of various types or an incomplete stigma (Evans 1955). The only recorded food plants are Poaceae (Beccaloni *et al*. 2008, quoting my records).

J40/1 *Morys valerius valerius* (sense Evans 1955, probably not Möschler 1879)

Figs. 28-32.

Möschler (1879) described *Apaustus valerius* from Colombia, based on a single female specimen. Godman (1900) examined the type and recognised this species from Central America, illustrating the male UPS, venation and genitalia from Mexican specimens (plate 98.47-49). Evans (1955) described *valda* Evans as a new subspecies from Mexico and Honduras, while recognising the nominate subspecies from Colombia to Brazil, with most records from Trinidad. However, although Evans (1955) attributed Godman's (1900) figure of the male genitalia to the nominate subspecies, given the locality of Godman's specimen (Mexico), his figure must be of ssp. *valda*. The distal part of the clasper of Godman's figure is deeply and smoothly divided between two short arms, whereas that shown by Evans (1955) has the two arms much longer and coming together to almost meet distally. Trinidad material that I have examined matches the illustration of *valerius* by Evans in this regard. Hayward (1950) treats *M. valerius* from Argentina based on a single female specimen, so although he illustrates the male genitalia, this cannot be of an Argentine specimen, and the illustration is so similar to the illustration of ssp. *valda* by Godman (1900) that it is likely to be a copy. Although Mielke (2004) treats *valda* as a subspecies of *valerius*, it may well be that it is a distinct species, based on the genitalia differences.

Möschler's (1879) description of *valerius* differs in some details from the species Evans (1955) treated as *valerius* (no spot in space 1B UPF, yellow-white 'wisp' in space 1B UNF, spots in spaces 2-5 UNH, veins yellowish UNH). O.H.H. Mielke (pers. comm. 2011) sent me photographs of the female type of *valerius*, which is in the Berlin Museum. It matches the description, but does not seem to be the species treated as *valerius* by Evans (1955), although a study of the genitalia will be needed to confirm this and clarify what species the type represents. Until then, I use the name *valerius* in the same sense that Evans (1955) used it.

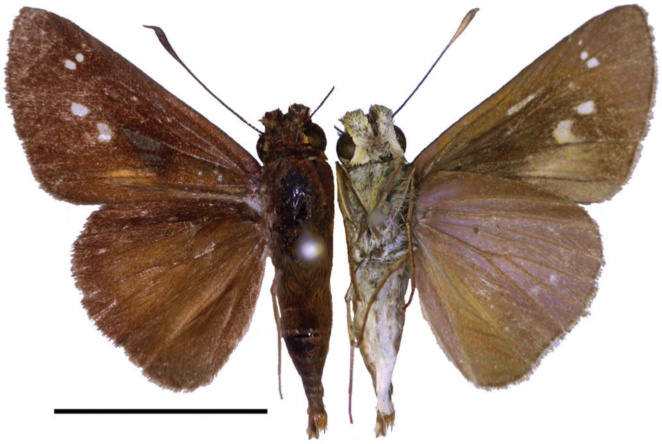

Fig. 28. ♂ *Morys valerius valerius*, Las Lomas, Spanish Farm, 17.xii.1980.

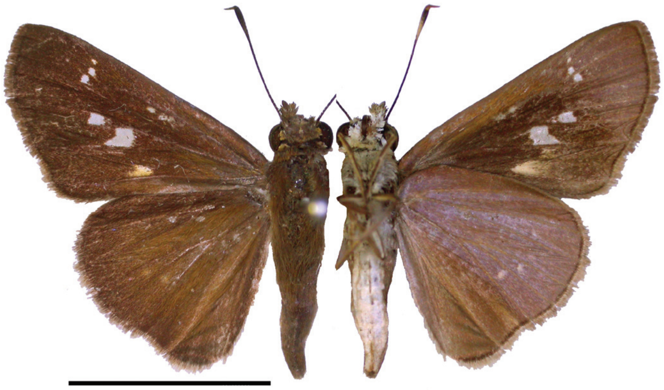

Fig. 29. ♀ *Morys valerius valerius*, Curepe, 26.ix.1979.

Godman (1900) noted that this species was labelled '*Pamphila cerdo* Boisd.' in the NHM; this name was not published by Boisduval, but was listed by Butler (1870) without any description and so is an unavailable *nomen nudum*. Kaye (1914) first recorded *M. valerius* from Trinidad as *Morys cerdo*, based on a specimen captured at St. Clair, Port of Spain, 31.xii.1912 by (K. St. A. Rogers). This record is repeated in Kaye (1921, no. 400).

The three UPF brands in the male are distinctive: against cell, from origin of vein 2 to origin of vein 3, wider nearer vein 2 and slightly triangular; two brands under vein 2 and parallel to it, aligned with basal part of the first brand (Fig. 28). UPF with diffuse yellow spot in space 1B, white hyaline spots in spaces 2, 3, 6, 7 and sometimes 8, and there may be an upper cell spot F, especially in the female; UNH is brown with a lilac sheen apart from spaces 1A-1C, and pale spots variably present in spaces 1C-6. The female is similar to the male, but the wings are longer and more rounded.

Records of 28 specimens (18♂♂, 10 ♀♀) show this species to be moderately common in the foothills of the Northern Range of Trinidad from Morne Catherine to Arima Valley, with scattered records from lowland central and southern Trinidad. Most records are from below 1000 ft. (305 m), but captures extend to around 1500 ft. (460 m) (♀ Morne Catherine, 6.viii.1979). There is one record from Gasparee Island off the NW peninsula of Trinidad (♂ 5.ii.1922 [N. Lamont], NMS). Captures are throughout the year, but with slightly more in December-February, i.e. early dry season.

Beccaloni *et al*. (2008) include my unpublished records of *Olyra latifolia* and *Setaria barbata* (Poaceae) as food plants in Trinidad. In Costa Rica, Janzen and Hallwachs (2011) have reared subspecies *valda* commonly from *Acroceras zizanioides* and *O. latifolia*, and occasionally from a dozen other Poaceae.

Fig. 30. ♂ *Morys valerius valerius,* collected as caterpillar on *Olyra latifolia*, in forest to north of Mt. St. Benedict, 1.v.1995, photo 23.v.1995, ref. 95/2A.

I reared this species from two caterpillars collected 1.v.1995 on *O. latifolia*, in the forest above Mt. St. Benedict (ref. 95/2), and from a prepupa collected 6.x.1994 on *S. barbata* in Port of Spain (ref. 94/61). The following is mostly based on the first collection. The leaf shelter was made by rolling the leaf upwards, with feeding distal to the shelter; it is not clear that any cuts were used to make the shelter. The mature final instar caterpillar measured 20 mm. Head rounded triangular (i.e. widest just above the base); slightly indented at vertex; ground colour white; heavy dark stripe from vertex, where it is red-brown, to stemmata; frons grey-green; occipital suture red-brown at vertex, shading to grey-green at and along adfrontal sutures; red-brown line near and parallel to lower half of occipital suture. T1 concolorous. Body dull green with yellow speckles; dorsal line darker; pale dorsolateral, lateral and sub-spiracular lines; legs and prolegs concolorous; spiracle A8 light brown, inconspicuous; other spiracles pale, inconspicuous. The wax glands are formed laterally on the ventral surface of A7 extending into the anterior half of A8.

The prepupa on *S. barbata* (ref. 94/61) was found on the underside of a leaf with no shelter, except that silk held the leaf slightly concave. The prepupa measured 24 mm, and I noted the wax glands as subventrally on the posterior margins of A6 and A7 and anterior margin of A8. The pupae measured 19-22 mm; they were slender,

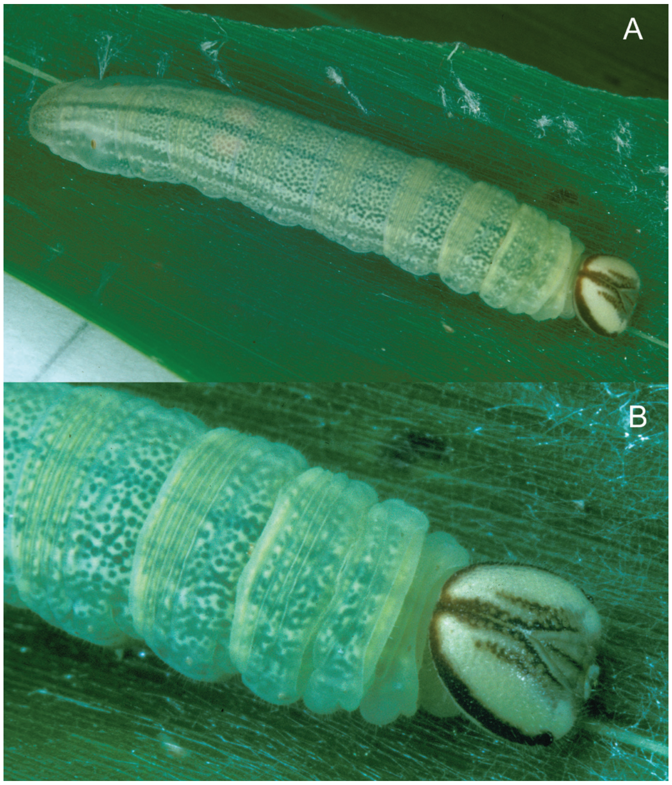

Fig. 31. Final instar caterpillar of *Morys valerius valerius,* collected on *Olyra latifolia*, in forest to north of Mt. St. Benedict, 1.v.1995, photo 1.v.1995, 20 mm, ref. 95/2A. **Above**, dorsolateral view; **Below**, detail of head and anterior segments.

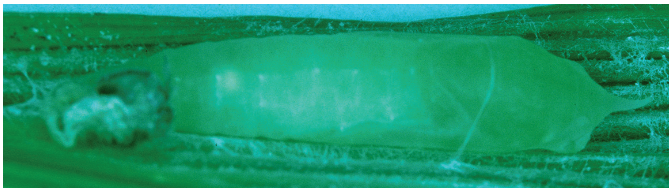

Fig. 32. Dorsolateral view of pupa of *Morys valerius valerius,* collected as prepupa on *Setaria barbata*, Port of Spain, 8.x.1994, 22 mm, ref. 94/61.

plain green, with a 2 mm frontal spike. Pupation lasted 9-12 days.

Another shelter collected at Mt. St. Benedict on *O. latifolia* on the same occasion (ref. 03/201) contained a final instar head capsule and five rather flimsy parasitic Hymenoptera cocoons, from which five small adult wasps emerged 2-3 days later. They have not been identified. However, the identity of the host is uncertain given the similarity of the caterpillars of *Morys*, *Cymaenes* and *Lerema* spp.

J40/2 *Morys compta compta* (Butler 1877)

Figs. 33-34.

This species was described from the Amazons (Butler 1877) from three localities, including both male and female specimens. Evans (1955) refers to a male type in the NHM, and Mielke and Casagrande (2002) formally designated a male from the type series as the lectotype. Evans (1955) treated *M. compta* as comprising two subspecies: the nominate ssp. from Venezuela and the Guyanas south to Paraguay, and ssp. *micythus* (Godman 1900) described from Mexico and found south to Ecuador.

The male genitalia are illustrated by Evans (1955), but the illustrations by Godman (1900, plate 99. 31) and Hayward (1950, plate viii.12) are of *M. geisa* (Möschler), the latter probably copied from the former.

Morys compta was recorded from Trinidad by Kaye (1914) citing specimens from St. Ann's Valley taken by himself and G.E. Tryhane. The same records are given in Kaye (1921, no. 407). There is a specimen in MGCL from Kaye's collection which he identified as *Euroto compta*, "Trinidad, '98, W.J. Kaye", which may well be the first of these. It is actually a potentially undescribed species of *Morys* identified by the late S.R. Steinhauser (A.D. Warren, pers. comm. 2011). I will try and treat this species in a future paper.

Kaye (1914, plate 30.8) described and illustrated *Euroto simplissima* Kaye from a male captured in Emperor Valley, Port of Spain, 3.ii.1913 by K. St. A. Rogers, and repeats this information in Kaye (1921, no. 409). Evans (1955) mis-spelt this name *simplicissima* and synonymised it with *M. compta*, based on Kaye's (1914) illustration. The type is in HEC and I have examined photographs of it. It is correctly synonymised under *M. compta*; the type has a brand under vein 2 and traces of a discal band UNH, both typical of *M. compta*, but not mentioned or illustrated by Kaye (1914) in the type description.

Both male and female have F spots in spaces 2, 3 and 6-8, although those in spaces 7 and 8 may be absent; a weak diffuse area in space 1B UNF; UNH brown with a reddish chestnut tint and paler spots variably in spaces 1C-7. The male brand consists of three sections: the largest along the base of space 2, wider above the base of vein 2; a streak in space 1B below vein 2 and an inconspicuous short streak below this. The female is larger with more rounded wings.

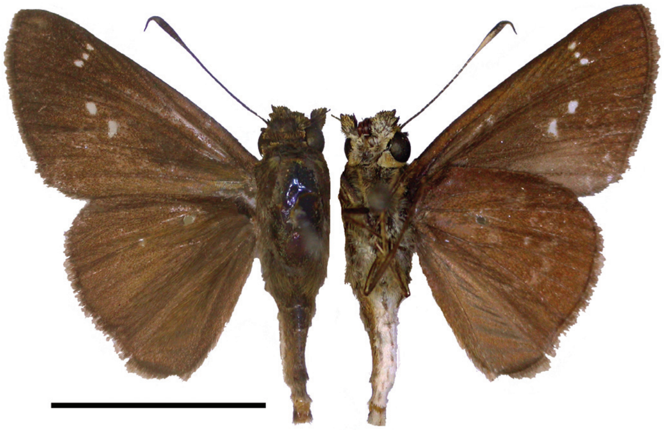

Fig. 33. ♂ *Morys compta compta*, Waller's Field, 17.ii.1982.

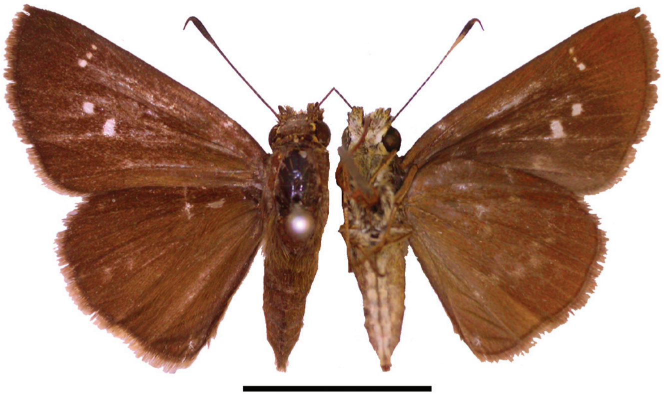

Fig. 34. ♀ *Morys compta compta*, Parrylands, 21.viii.1980.

Trinidad records include 36 ♂♂ and 10 ♀♀, mostly from the Northern Range, from Point Gourde to Quare Road, but with several records from central and southern Trinidad. Although most captures are at lower altitudes, they extend to 2300 ft. (700 m, ♀, Morne Bleu Textel, 16.i.1988). Captures are from forested areas, secondary forest and suburban areas. Roadside flowers, e.g. *Bidens pilosa*, are used as nectar sources. Adults can be found at any time of year, but captures are most common early in the dry season (January-February) and least common at the beginning of the rainy season (May).

I have reared this species from a caterpillar collected on a grass, *Paspalum virgatum* (Beccaloni *et al*. 2008). The caterpillar was collected at St. Augustine, 17.iii.1982 (ref. 82/52), but very little detail was recorded. The caterpillar was in a shelter made from the rolled, basal part of the leaf, and when the pupa was formed on the lid of the rearing container, it was surrounded by white waxy powder. The following notes are based on the remains preserved with the pinned adult. Pupa 21 mm; translucent; cylindrical, elongate at ends; frontal spike short with black apex; proboscis sheath reaches base of cremaster; cremaster broad, pointed. Final instar caterpillar head approximately 2.2 x 3.1 mm wide x high; pale brown ground colour; dark brown stripe from apex laterally to stemmata; diffuse brown line from apex to apex; diffuse brown line down epicranial suture, continuing adjacent to adfrontals on epicranium to base of adfrontals; diffuse line running parallel to epicranial suture to base of adfrontals; narrow brown line down centre of clypeus; covered with white waxy powder; scattered pale erect setae. T1 with a narrow pale brown dorsal plate; body with scattered pale inconspicuous setae. Penultimate instar head 1.7 x 2.0 mm wide x high; rugose; scattered inconspicuous pale erect setae; pale brown with brown and dark brown markings; posterior collar narrowly dark brown with a wider brown border, and anterior to this an area of pale brown; dark brown stripe from vertex over apex laterally to stemmata; brown stripe down epicranial suture, extending on epicranium along the margin with the adfrontals to the base of the adfrontals; diffuse, brown stripe parallel to epicranial suture to base of adfrontals; clypeal sutures narrowly brown; brown stripe down middle of clypeus. N-2 instar caterpillar head 1.2 x 1.4 mm wide x high; dark brown-black; rugose, shiny; inconspicuous short, pale, erect setae.

J40/3 *Morys geisa geisa* (Möschler 1879)

Figs. 35-39.

Möschler (1879) described this species from Colombia based on two males. O.H.H. Mielke (pers. comm. 2011) sent me photographs of a male specimen in the Berlin Museum labelled lectotype; apart from some loss of colour, and the spot in space two being more convex basally and concave distally, it seems a good match to the male shown in Fig. 35. Godman (1900) states that he examined "the type" and found it to be the same as *M. compta*. However, Evans (1955) treats *M. geisa* and *M. compta* as separate species, as followed here.

Based on Evans' treatment, the male venation and male genitalia illustrated by Godman (1900, plate 99.31) as *M. compta* are *M. geisa*. Similarly, the male genitalia illustrated by Hayward (1950, viii.12) as *M. compta* (probably copied from Godman 1900) and of *M. geisa* (viii.14), are both *M. geisa*.

Schaus (1902) described *Euroto etelka* Schaus from a Trinidad male. His description includes a cell spot and two rows of pale spots UNH, but examination of the type indicates that one apparent row is damaged to the specimen, and it otherwise closely matches the specimen shown here (Fig. 35). It is a synonym of *Morys geisa* (Evans 1955; Mielke 2004). Kaye (1940, no. 409a) adds *Euroto etelka* to his Trinidad catalogue as a separate species, commenting that it was "described from a Trinidad specimen".

Fig. 35. ♂ *Morys geisa geisa*, San Miguel Valley, old cacao estate, 17.x.1979.

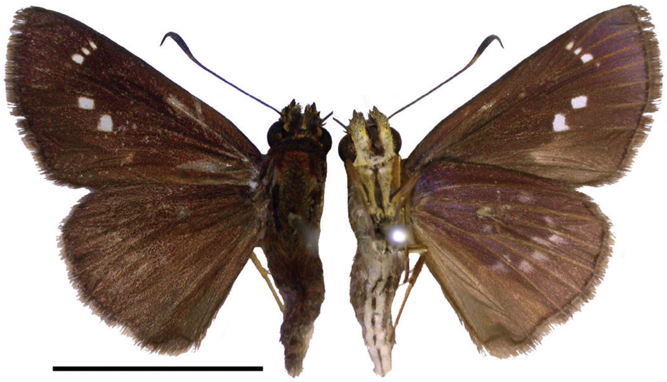

Fig. 36. ♀ *Morys geisa geisa*, collected as caterpillar on *Orthoclada laxa*, Arena Forest, 6.v.1995, ref. 95/15.

Kaye (1914, plate 30.14) described the same species as *Phanis sylvia* Kaye from "Trinidad, St. Ann's Valley (G.E. Tryhane)", and illustrates a male specimen. By implication, only one specimen was involved, although a series is possible. Kaye (1921, no. 404) adds no further information. Evans (1955) mis-spelt Kaye's species as *silvia* when he synonymised it with *M. geisa* (Mielke 2004). Evans (1955) states that the type is in the NHM, but although there are males in the NHM from St. Ann's Valley and Trinidad (without locality) in the NHM, and a type label is placed against the latter, there is no indication that either is the type (e.g. a label in Kaye's writing). The type has not been located in MGCL which includes Kaye's collection (A.D. Warren, pers. comm. 2011) so it may be that the type is lost. Kaye (1914) includes in his description of *Phanis sylvia* "hind-wing … below the veins showing clearly pale brownish on a pale purplish brown ground; a series of elongated grey spots between

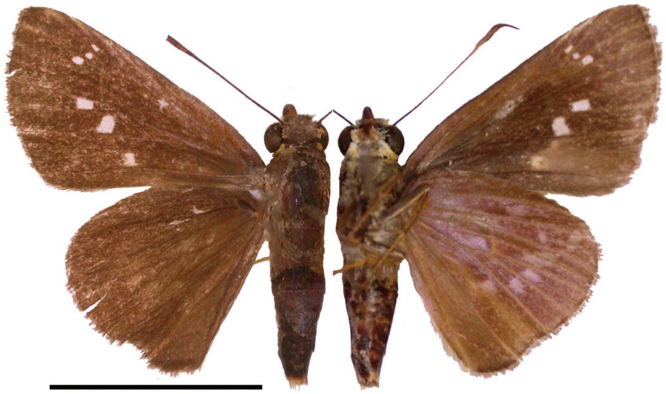

Fig. 37. ♀ *Morys geisa geisa*, Lalaja Ridge, 18.xii.1981.

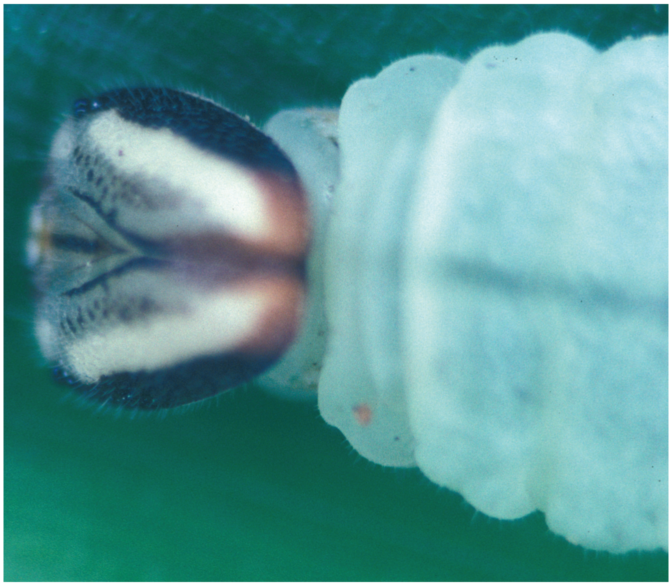

Fig. 38. Detail of head of final instar caterpillar of *Morys geisa geisa,* collected on *Orthoclada laxa*, Arena Forest, 6.v.1995, 21 mm, ref. 95/15.

Fig. 39. Lateral view of pupa of *Morys geisa geisa,* collected on *Orthoclada laxa*, Arena Forest, 21.v.1995, 22 mm, ref. 95/15.

the veins midway between the cell and outer margin", whereas Kaye's illustration shows a much darker UNH. Based on the description, *sylvia* does seem to be correctly placed as a synonym of *M. geisa*.

In both sexes (Figs. 35-36) there are white hyaline spots UPF in spaces 2, 3 and 6-8, and a trace of a diffuse pale spot in space 1B; UNF there is a diffuse pale area in space 1B; the apex UNF and the UNH apart from spaces 1A-1C are dark brown with a purple sheen; UNH has pale blue-grey spots in spaces 1C-7, that in space 4 being elongate and displaced basally compared to the others. The male has a two-part black brand along the base of space 2, widest above the base of vein 2, and adjacent to this a line below vein 2 in space 1B; otherwise the sexes are similar apart from the more pointed forewings of the male.

Twenty records from Trinidad (14 ♂♂, 6♀♀) show this is only a moderately common species. However, it is widespread, with records from Cedros Forest Reserve in the far south-west (♀, Southern Main Road, milestone 66¼, 2.ix.1980) to Toco in the far north-east (♂,♀ 3.iii.1939 [N. Lamont], UWI, NMS), and from near sea level to around 2200 ft. (670 m) on the north face of El Naranja (♂ 11.viii.1979). Records are mostly from more or less natural forest areas, extending into secondary forest, and 80% of captures were made between October and March.

The only published food plant record seems to be that by Beccaloni *et al*. (2008), citing my personal communication of a record from a grass, *Orthoclada laxa*, in Trinidad. This record was based on collection 95/15 in Arena Forest, 6.v.1995 (Fig. 36). I have also reared a specimen from a prepupa collected 6.x.1994 on *Setaria barbata* in Port of Spain (ref. 94/61). At the time, the early stages appeared to me to be the same as those of *M. valerius* above and no observations were recorded, but fortunately photographs were taken (Figs. 38-39).

?*Morys* sp.

Fig. 40.

I have a single female specimen from Point Gourde, 12.vii.1997, which is currently unidentified. See under *M. compta* above regarding the species which Kaye treated as *M. compta*. This specimen has white hyaline spots in spaces 2, 3, 6 and 7 F, and the UNH is plain brown with a chestnut tint.

Fig. 40. Unidentified ♀ ?*Morys* sp., Point Gourde, 12.vii.1997.

Tigasis Godman 1900 in Godman 1899-1901

Fig. 41.

This genus of nine species (Mielke 2004) occurs from Central America to Brazil, and all species seem to be uncommon (Evans 1955). The males have a more or less complete stigma from base vein 3 to vein 1 (Evans 1955).

Beccaloni *et al*. (2008) include no food plant records, but Janzen and Hallwachs (2011) have reared *Tigasis simplex* (Bell) 20 times in Costa Rica on *Rhipidocladum racemiflorum* (Poaceae). Based on their photos of the caterpillar, I believe that a parasitized caterpillar that I collected on *Setaria barbata* at Mt. St. Benedict, 5.x.1994 (ref. 94/59B) was a *Tigasis* sp., and given the locality, likely to be *T. garima garima* (Schaus). It was found in a leaf shelter made from the apical portion of a leaf, the leaf lamina rolled downwards on each side to make a tapered cone, and the lamina eaten to the midrib on both sides basal to this, allowing the midrib to flex so that the shelter hung downwards. The caterpillar (Fig. 41) was 20 mm and relatively slender, compared to a caterpillar of *Cymaenes tripunctus theogonis* collected in a similar shelter on the same food plant on the same occasion (ref. 94/89A). Head translucent light green; posterior margin slightly darker; a narrow brown line from vertex laterally to mouthparts; anterior to this line, a broad white line; a narrow brown line from vertex down epicranial suture, continuing as a finer line halfway down frons. T1 concolorous with body. Body dull translucent green with tightly packed yellow speckles in a broad subdorsal line which defines the dorsal line, and a narrow dorsolateral line; trachea visible through cuticle as a lateral line; spiracles and all legs concolorous. A solitary braconid parasitoid emerged from the caterpillar and spun a flimsy white cocoon in the leaf shelter, emerging 2-3 weeks later.

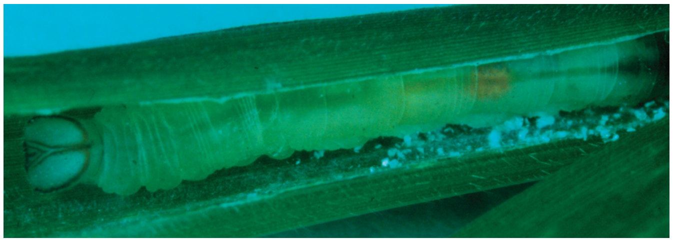

Fig. 41. Probable final instar caterpillar of *Tigasis* sp., collected on *Setaria barbata,* at Mt. St. Benedict, 5.x.1994, photo 8.x, 20 mm; ref. 94/59B.

J44/1 *Tigasis garima garima* (Schaus 1902)

Figs. 42-43.

This species was described from Trinidad (Schaus 1902) and is also reported from Ecuador (Evans 1955). A second subspecies *massarus* (Bell 1940) occurs in southern Brazil (Evans).

Although Bell (1940, Fig. 4) illustrates the male genitalia of ssp. *massarus*, the only illustration for ssp. *garima* is that provided by Evans (1955). However, Evans' (1955) illustration of the clasper of *massarus* shows some differences from Bell's (1940) figure, so the situation may be more complicated, with additional taxa. Anyway, the application of the name *garima* to Trinidad material is clear, given this is the type locality.

Kaye (1940, no. 399B) includes this species in his additions to the catalogue stating that he had not seen this species.

UPF both sexes have a white spot in lower space 1B, white hyaline spots in spaces 2 (wider at top and bottom than middle), 3, 6, 7 (sometimes) and both upper and lower cell spots; a more or less diffuse white area in space 1B UNF; UNH brown with only very slight purple sheen, and variable pale spots in spaces 1C-3, 5 and end cell. The male brand from below the origin of vein 3 to vein 1 is interrupted mid space 1B. The female has longer, more rounded forewings.

I have only six Trinidad records (4♂♂, 2♀♀). Although *T. g. garima* is widespread in Trinidad, the locali-

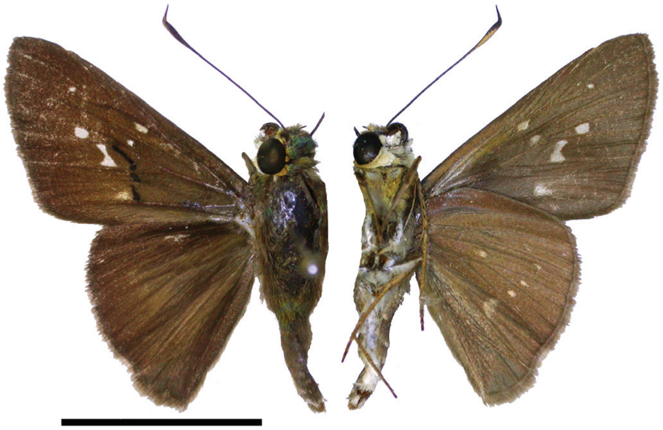

Fig. 42. ♂ *Tigasis garima garima*, Mt. Tamana summit ridge, 14.x.1995.

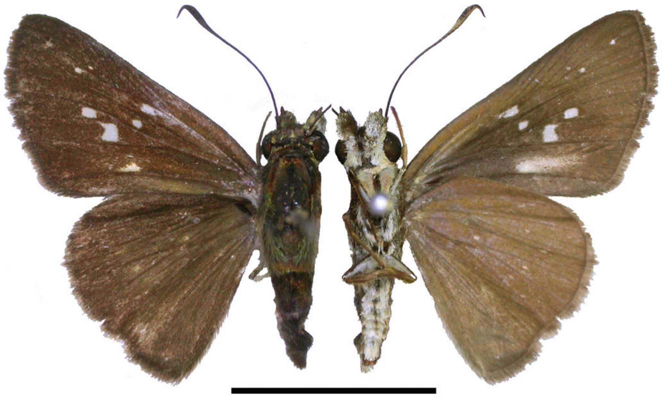

Fig. 43. ♀ *Tigasis garima garima*, Rio Claro-Guayaguayare Road, eupatorium flowers, 11.x.1993.

ties show no clear pattern: Manzanilla Windbelt Reserve, Mt. Tamana summit ridge, Northern Mountains, Rio Claro-Guayaguayare Rd., Mt. St. Benedict. However, four of the specimens with months of capture were taken in October, one at eupatorium flowers (♀, Rio Claro-Guayaguayare Rd., 11.x.1993).

The biology and food plants are not known (Mielke 2005; Beccaloni *et al*. 2008), but see comments under *Tigasis* above.

J44/4 *Tigasis physcoa* (Hewitson 1868)

Figs. 44-45.

This rare species was only known from Venezuela (Hewitson 1868; Evans 1955) until Cock (1982) first reported it from Trinidad. The only illustration of the male genitalia is that in Evans (1955).

The male (Fig. 44) generally has only a very small white hyaline spot in space 3, while the female (Fig. 45) has spots in spaces 2 (widest against vein 2), 3 and 6-7. The apex UNF and UNH is brown with a strong chestnut-purple tint and variable yellow spots in spaces 1C-5 and end cell. The black male brand is almost continuous from the base of space 3 to vein 1B, and hardly interrupted at mid space 1B.

Fig. 44. ♂ *Tigasis physcoa*, Maracas-Caura Ridge, 14.iii.1982.

Fig. 45. ♀ *Tigasis physcoa*, El Naranja, 2000 ft. (610 m), in cop., 19.vi.1979.

I have records of seven males and four females of this species from Trinidad, all taken on the higher parts of the Northern Range at around 2000 ft. (610 m): Maracas-Caura Ridge; north side of El Naranja; Andrew's Trace (Arima-Blanchisseuse Road, milestone 9¾); Arima-Blanchisseuse Road, milestone 10½, Textel track; by Morne Bleu Textel Installation; and on the ridge from the Morne Bleu Textel Installation to Morne Bleu. The months of capture are evenly spread through the year.

There are no records of the food plants or early stages (Mielke 2005; Beccaloni *et al*. 2008).

DISCUSSION

Based on their early stages as documented here, *Cymaenes*, *Cobalopsis*, *Lerema* and *Morys* could all be congeneric - compare the caterpillars of *Cymaenes tripunctus* (Fig. 4), *Cobalopsis nero* (description in text), *L. ancillaris* (Fig. 25), *Morys valerius* (Fig. 31), *M. compta* (description in text) and *M. geisa* (Fig. 38). Conversely, the caterpillars of *Arita arita* (Fig. 17) and *Tigasis* sp. (Fig. 41) are obviously different, and not necessarily closely related. Equally, the pupae of *Cymaenes*, *Cobalopsis*, *Lerema* and *Morys* are similar – cylindrical, elongate at both ends, green, with or without pale longitudinal subdorsal and dorsolateral lines, while that of *A. arita* (Fig. 18) is brown, more rounded and has no frontal spike. Cock and Congdon (2012) have noted a similar pattern in the tribe Baorini in Africa where in one genus, *Parnara*, the pupa is brown, rounded and without a frontal spike, while the others that are known (*Zenonia*, *Pelopiodas*, *Borbo* and *Gegenes*) are very similar to those grouped here, as well as those of a variety of genera in other tribes of Hesperiinae. The authors hypothesise that this shared pupal form and colouring reflects a common need for camouflage for those species that do not make fully enclosed pupal shelters, but rather pupate in a partly open shelter or under a grass or palm leaf with no shelter. Conversely those species that form a completely closed pupal shelter do not need to be camouflaged in shape or colour and so lack the elongate shape, frontal spike and green colouring.

Given the similarity of the caterpillars shown for *Cymaenes*, *Cobalopsis*, *Lerema* and *Morys*, it may well be that these genera form a monophyletic group. Amongst the main differences between the genera is the presence or absence, and form when present, of the male brands UPF. These secondary sexual characters are thought to be relatively easily lost within genera, perhaps controlled by a single gene (Burns 1964, 1989; De Jong 1982) so that the differences in brands may not be as important phylogenetically as they seem. Patterns in the form of the genitalia are likely to be more important in defining these generic groups in future.

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The type specimens of *Cymaenes finca* shown in Figs. 6 and 7 are in the NHM, and the specimen of *Cymaenes* sp. nr. *campestris* in Fig. 8 is in NMS. I thank Andy Warren and James Logan who checked the MGCL and HEC respectively for types and historical specimens, and sent me photographs of key specimens; Olaf H.H. Mielke who shared photographs of type specimens with me; and Scott Alston-Smith for adding information based on his observations.

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A Preliminary Survey of the Harvestmen (Arachnida: Opiliones) of Tobago, West Indies

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ABSTRACT

Eleven species of harvestmen were collected from along the trail connecting the Speyside overlook to Pigeon Peak on Tobago, including representatives of the families Agoristenidae, Cosmetidae, Cranaidae, Manaosbiidae, Sclerosomatidae, and Stygnidae. The most abundant species were *Cynortula granulata* Roewer 1912 (Cosmetidae), *Paecilaema inglei* Goodnight and Goodnight 1947 (Cosmetidae), *Rhopalocranaus albilineatus* Roewer 1932 (Manaosbiidae) and *Phareicranaus calcariferus* (Simon 1879) (Cranaidae). We also captured adults of *Prionostemma vittatum* Roewer 1910, *Avima intermedia* (Goodnight and Goodnight 1947) and *Stygnoplus biguttatus* Pinto-da-Rocha 1997. With the exception of *P. calcariferus*, each of these collections represent a new record for Tobago. In this paper, we also provide descriptions of the male reproductive anatomy for each species as well as notes on natural history, including the association of cyanobacteria with a sclerosomatid harvestman and stridulation by *C. granulata*.

Key words: biogeography, Caribbean, Laniatores, Neotropical, taxonomy, faunistics.

INTRODUCTION

Harvestmen (also known as daddy longlegs or harvest spiders) belong to the Opiliones, the third largest order of arachnids (approximately 6,500 species: Kury 2011). Since 2003, we have engaged in field and laboratory-based studies of harvestmen from Trinidad (Townsend *et al.* 2008a). These investigations have provided new insights into the biology of these arachnids, especially with respect to habitat use (Burns *et al.* 2007; Proud *et al.* 2011; Townsend *et al.* 2011a), behavioral ecology (Hunter *et al.* 2007; Proud and Townsend 2008), interactions with parasitic and phoretic mites (Townsend *et al.* 2008b), and developmental morphology (Townsend *et al.* 2009). In addition to a key to families, Townsend *et al.* (2008a) provided the first records for the Kimulidae in Trinidad. Since the publication of this paper, we have confirmed the identity of these species that we had previously listed as unidentified including *Cynortula granulata* Roewer 1912 (*Cynortula* sp. 1), *C. undulata* Roewer 1947 (*Cynortula* sp. 2), *Paecilaema paucipustulatum* Roewer 1947 (*Paecilaema* sp. 2), and *Avima intermedia* (Goodnight and Goodnight 1947) (*Trinella* sp.).

In comparison to the harvestmen fauna of Trinidad, very little is known about the natural history, diversity or distribution of harvestmen from Tobago. Cokendolpher and Camilo-Rivera (1989) provided a single combined species list for Trinidad and Tobago. Similarly, Kury (2003) did not distinguish between the faunas of these islands, and listed the only confirmed record for Tobago (Pinto-da-Rocha and Kury 2003) as being the cranaid harvestman *Phareicranaus calcariferus* Roewer 1932.

The primary objective of our study was to examine the diversity of harvestmen in Tobago. In the field, we also made natural history observations concerning microhabitat selection, diurnal and nocturnal activity, parental care, and anti-predatory behaviors. In efforts to identify undescribed species and confirm the distribution of known taxa, we also dissected and compared the reproductive anatomy of adult males for species from Tobago and Trinidad.

METHODS

Harvestmen were collected by hand from vegetation and beneath logs and palm fronds from 10-14 August, 2010. All specimens were encountered along the trail connecting the Speyside overlook to Pigeon Peak, and within hiking distance of our base camp (11N 17.845 60W 32.934 at 1331 ft. elevation). Primary habitat in this area is lower montane rainforest.

Sampling occurred along trails during morning, afternoon and evening hours. Prior to collection, several individuals were observed haphazardly for brief periods

(5-10 min.) of time. Voucher specimens of adults were preserved in 70% ethanol.

In the laboratory, specimens were photographed with a Leica EZD4 digital stereomicroscope. Genitalia of adult males were dissected and prepared for examination with scanning electron microscopy (SEM). We also dissected penises from harvestmen collected from Trinidad (Townsend *et al.* 2008a) as well as from select museum specimens from the American Museum of Natural History, New York, U.S.A. (AMNH). Penises were dehydrated in a graded ethanol series, dried with hexamethyldisilizane, sputter-coated with gold, and photographed with a Hitachi S-3000N SEM in the Microscopy Center at the University of Louisiana at Lafayette, USA. Voucher specimens will be deposited in the AMNH collection.

RESULTS AND DISCUSSION

We collected 11 species of harvestmen including representatives of 6 families (Table 1). However, we did not capture any individuals for the families Kimulidae, Samoidae, Stygnommatidae and Zalmoxidae, taxa that occur in forested habitats in Trinidad (Table 1). Individuals of these families predominantly occur in the leaf litter microhabitat (Townsend *et al.* 2008a). The visual survey method that we employed in Tobago is biased against the collection of small, secretive species that occur primarily in the leaf litter. Thus, it is possible that representatives of these families may occur in Tobago and that we simply failed to find them.

In Tobago, our field observations indicate that the most common species of harvestmen are *Cynortula granulata* (Cosmetidae), *Paecilaema inglei* Goodnight and Goodnight 1947 (Cosmetidae), *Prionostemma* sp. 6 (Sclerosomatidae), *Prionostemma* sp. 7, *Rhopalocranaus albilineatus* Roewer 1932 (Manaosbiidae), and *Phareicranaus calcariferus* (Simon 1879) (Cranaidae). These species occurred in most habitats and were locally abundant in several locations. In contrast, we found relatively few individuals of *Cranellus* sp. (Manaosbiidae), *Stygnoplus biguttatus* Pinto-da-Rocha 1997 (Stygnidae), *Avima* spp. (Agoristenidae), and *Prionostemma vittatum* (Sclerosomatidae). Our comparative study of reproductive anatomy revealed that there are several species of harvestmen that may be endemic to Tobago. These taxa include *Cranellus* sp. (Figs. 2E-F, 6A-B), *Prionostemma* spp. (Figs. 4A-D, 6G-J), and *Avima* sp. (Figs. 1A, 5A-B). The following is a detailed summary of our observations of species for each family. In addition, we provide a description of penis morphology for each species.

Agoristenidae

Trinella, the largest genus in the subfamily Leiosteninae, was recently found to be a junior synonym of *Avima* (Villarreal and Kury 2009). The agoristenid species that occur in Trinidad and Tobago are members of this genus. Male *Avima* have relatively large chelicerae (Fig. 1A) in comparison to females (Fig. 1B). Leg I of these harvestmen is filiform and much narrower than legs II-IV (Figs. 1A-B). The two species from Tobago are easily distinguished by their dorsal coloration. In contrast to *A. albiornata* from Trinidad which has white spots on the third free tergite and anal operculum, *Avima* sp. from Tobago has large white spots on the lateral margins of the dorsal scutum (Figs. 1A-B). Adult *A. intermedia* lack these spots and have a relatively uniform brown dorsum, with a darker central region on the opisthosoma (Fig. 1C). The penises of these harvestmen (Figs. 5A-E) have a truncus with an apical ventral plate and a stylus with dorsal longitudinal crest (Pinto-da-Rocha and Kury 2007). As with the penises of other *Avima* spp. (Pinto-da-Rocha 1996), the trunci of the Trinidad and Tobago species have 3 lateral pairs of bifid setae with a single glans. In *Avima* spp. from Tobago (Figs. 5A-D), there were no single setae above the bifid setae on the truncus and the most variable characters between species were the relative length and shape of the stylus. We also observed interspecific variation (Figs. 5A-C) in the shape of the ventral plate.

We collected *Avima* spp. from leaf litter, palm fronds and a shaded cove-like area adjacent to a trail. Most individuals were adults (n = 6 for *Avima* sp., n = 4 for *A. intermedia*), but we did capture one late nymph.

Cosmetidae

We collected two species for this family: *Cynortula granulata* (Figs. 1E-F) and *Paecilaema inglei* (Figs. 1D). These species are easily distinguished on the basis of relative body size, dorsal armature, tarsal formula and coloration. *Paecilaema* is larger with respect to scutal length (2-3 mm) and has larger paired, spiniform tubercles on the dorsum. The dorsum of adult *P. inglei* is covered in small, scattered white spots (Fig. 1D). Males of *Paecilaema* have enlarged chelicerae in comparison to females, whereas the chelicerae of male and female *C. granulata* are very similar in size. In males of both species, the basal tarsal segments of leg I are enlarged. In *Paecilaema*, there are seven tarsomeres on leg I, whereas in *Cynortula*, there are only six. The penises of these harvestmen (Figs. 5F-L) have a relatively long truncus, with a distal end consisting of a ventral plate and a dorsal stylus with a crest (Kury and Pinto-da-Rocha 2007). There are 2-3 distolateral curved setae and 2 basal straight setae on the lateral border of the ventral plate. We observed interspecific variation (Figs. 5F-L) in the shape of the distal border of the ventral plate, the relative size of the glans, and the number of distolateral curved setae on the ventral plate. However, comparisons with multiple (3-5) speci-

Table 1. The harvestmen fauna of Trinidad and Tobago. All species records from Tobago are new, with the exception of *P. calcariferus* (Kury 2003; Pinto-da-Rocha and Kury 2003). X* denotes taxa confirmed by Townsend *et al.* (2008a).

Taxa	Tobago	Trinidad	Venezuela
Agoristenidae			
Avima albiornata (Goodnight and Goodnight 1947)		X	
Avima intermedia Goodnight and Goodnight 1947	X	X*	
Avima leiobuniformis (Šilhavý 1973)		X*	
Avima sp.	X		
Cosmetidae			
Cynortula granulata Roewer 1912	X	X*	
Cynortula modesta (Sørensen 1932)		X	
Cynortula undulata Roewer 1947		X*	
Libitiosoma granulatum Roewer 1947		X	
Paecilaema adspersum Roewer 1947		X	
Paecilaema inglei Goodnight and Goodnight 1947	X	X*	X
Paecilaema paucipustulatum Roewer 1947		X*	
Vonones testaceus Roewer 1947		X	
Cranaidae			
Phareicranaus calcariferus (Simon 1879)	X	X*	X
Kimulidae			
sp. 1		X*	
sp. 2		X*	
sp. 3		X*	
Manaosbiidae			
Cranellus montgomeryi Goodnight and Goodnight 1947		X*	
Cranellus sp.	X		
Rhopalocranaus albilineatus Roewer 1932	X	X*	X
Samoidae			
Maracaynatum trinidadense Šilhavý 1979		X*	
Pellobunus longipalpus Goodnight and Goodnight 1947		X*	
sp. 3		X*	
Sclerosomatidae			
Holcobunus aureopunctata Roewer 1953		X	
Prionostemma fulginosum Roewer 1953		X	
Prionostemma insulare Roewer 1953		X*	X
Prionostemma referens Roewer 1953		X	
Prionostemma vittatum Roewer 1910	X	X*	X
Prionostemma sp. 5		X*	
Prionostemma sp. 6	X		
Prionostemma sp. 7	X		
Stygnidae			
Stygnoplus clavotibialis (Goodnight and Goodnight 1947)		X*	X
Stygnoplus biguttatus Pinto-da-Rocha 1997	X		
Stygnommatidae			
Stygnomma sp.		X*	
Zalmoxidae			
Ethobunus tuberculata (Goodnight and Goodnight 1947)		X	X

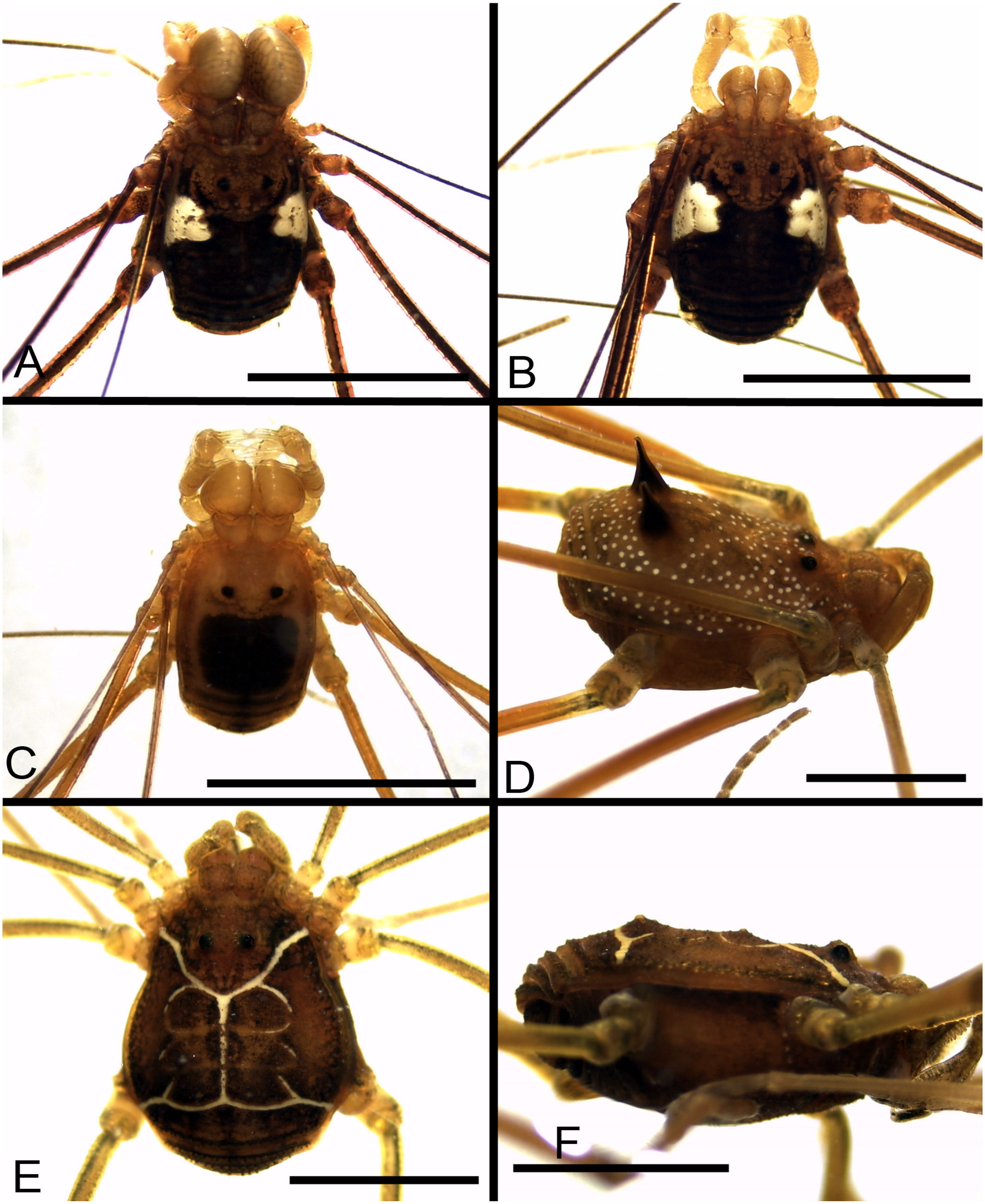

Fig. 1. Photographs of harvestmen from the families Agoristenidae and Cosmetidae. **A.** Dorsal view of a male *Avima* sp. (Agoristenidae). **B.** Dorsal view of a female *Avima* sp. **C.** Dorsal view of *A. intermedia*. **D.** Lateral view of *Paecilaema inglei* (Cosmetidae). **E.** Dorsal view of a male *Cynortula granulata* (Cosmetidae). **F.** Lateral view of a female *C. granulata.* Scale bars = 3 mm.

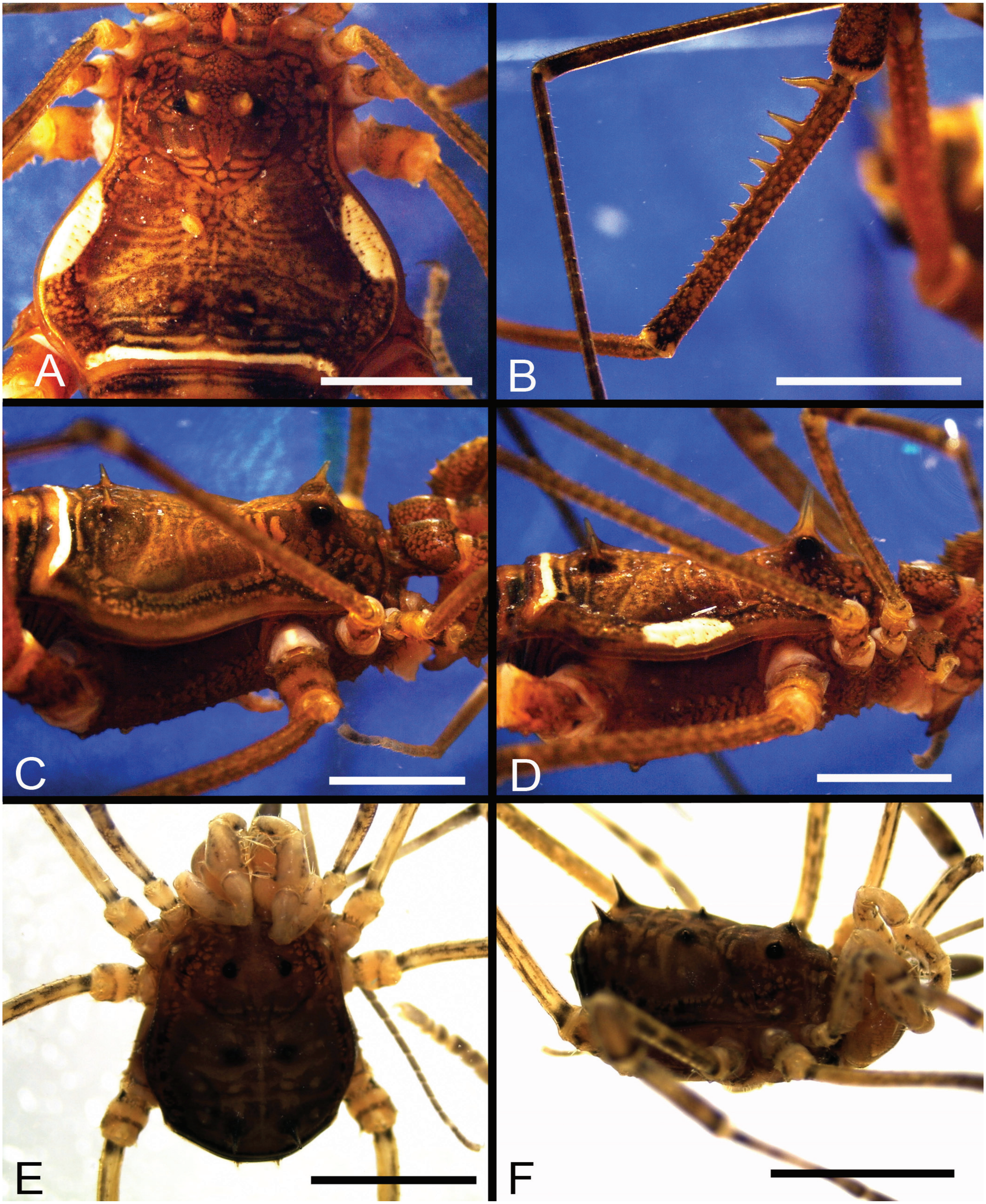

Fig. 2. Photographs of the harvestmen *Phareicranaus calcariferus* (Cranaidae) and *Cranellus* sp. (Manaosbiidae). **A.** Dorsal view of male *P. calcariferus*. **B.** Lateral view of left tibia IV of male *P. calcariferus*. **C.** Lateral view of male *P. calcariferus*. **D.** Lateral view of male *P. calcariferus*. **E.** Dorsal view of male *Cranellus* sp. **F.** Lateral view of male *Cranellus* sp. Scale bars = 3 mm.

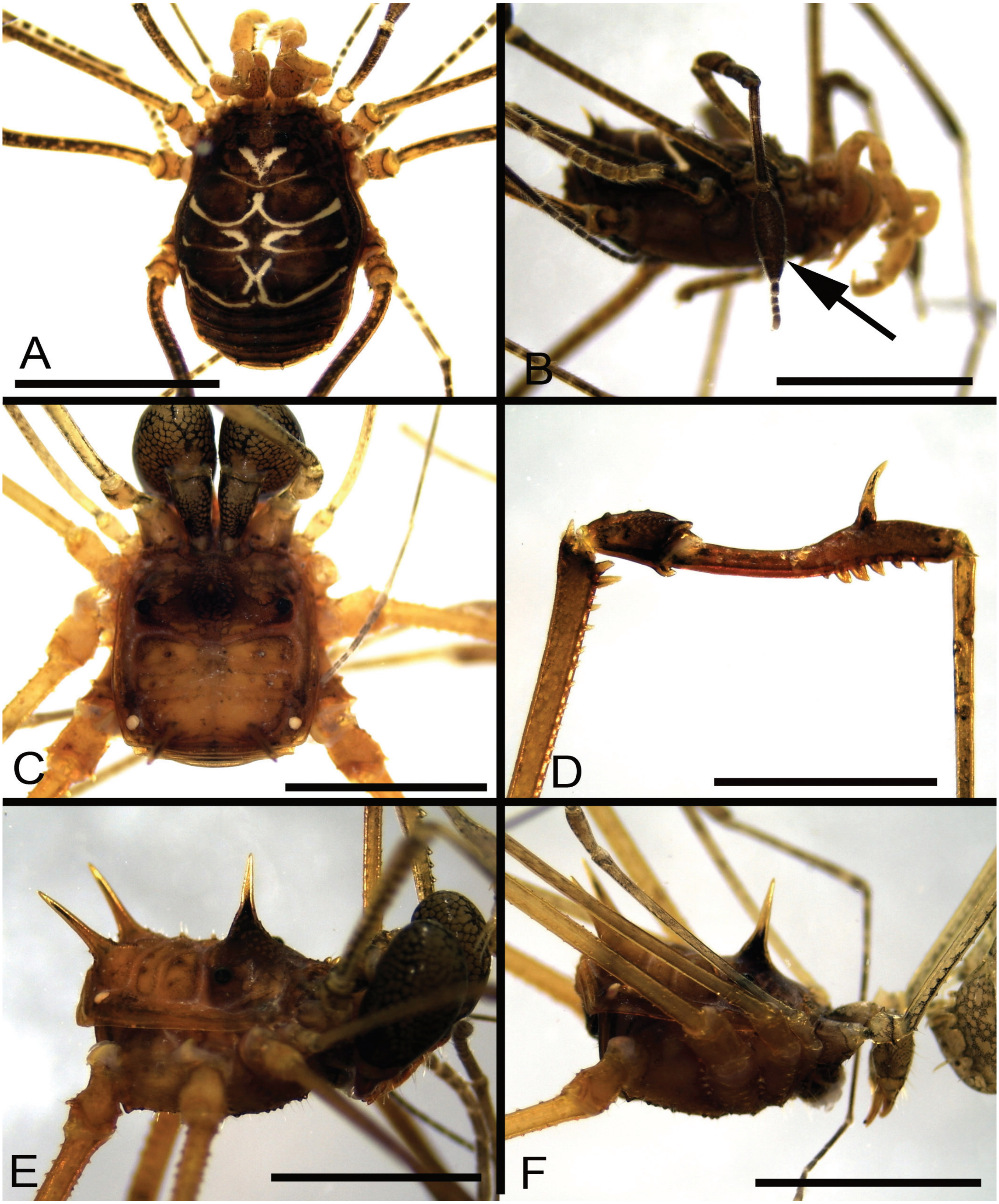

Fig. 3. Photographs of the harvestmen *Rhopalocranaus albilineatus* (Manaosbiidae) and *Stygnoplus biguttatus* (Stygnidae). **A.** Dorsal view of female *R. albilineatus*. **B.** Lateral view of male *R. albilineatus*, arrow indicates enlarged basitarsal segments on leg I. **C.** Dorsal view of male *S. biguttatus.* **D.** Lateral view of femur, patella and tibia IV of male *S. biguttatus*. **E.** Lateral view of male *S. biguttatus*. **F.** Lateral view of female *S. biguttatus*. Scale bars = 3 mm.

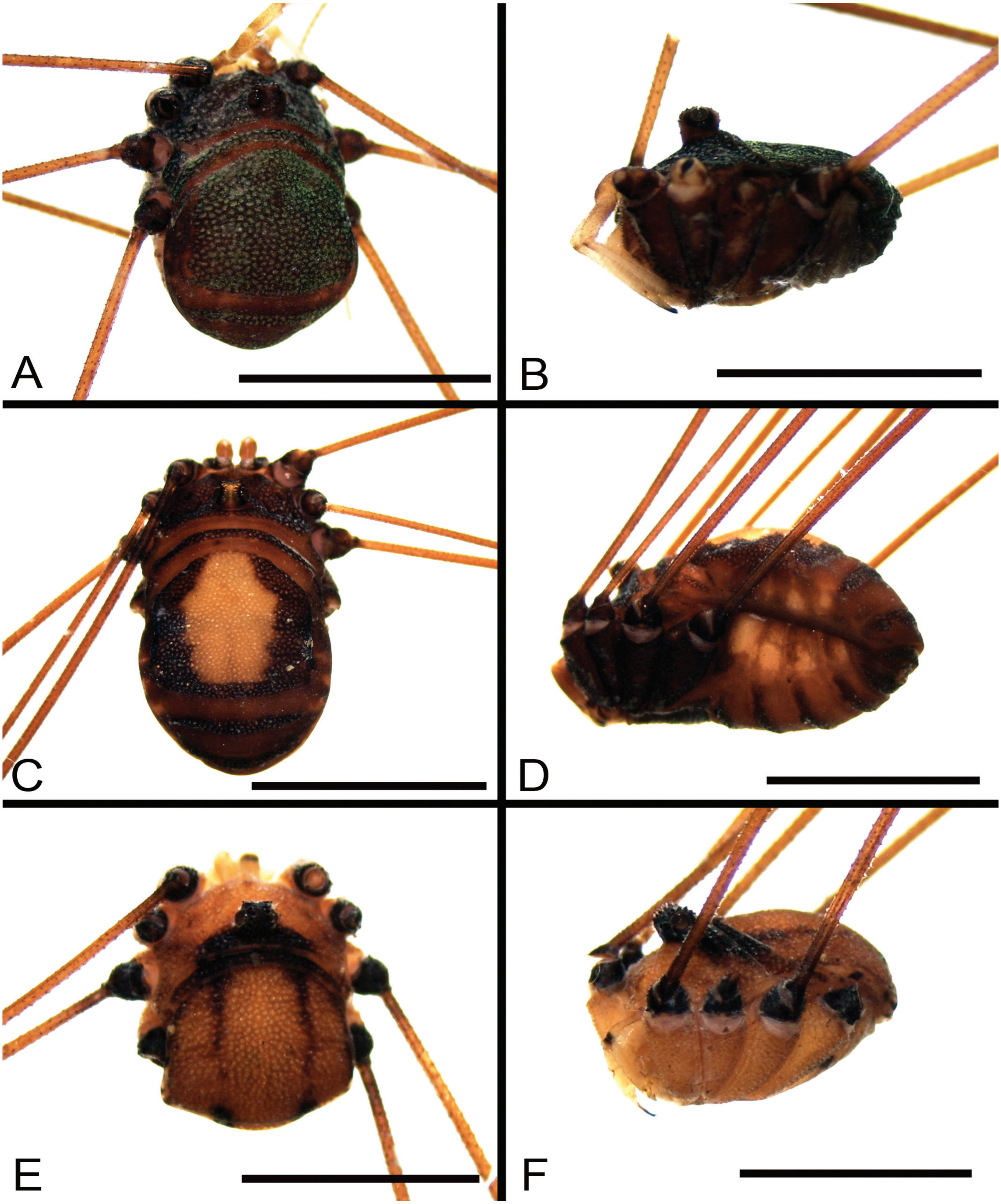

Fig. 4. Photographs of harvestmen from the family Sclerosomatidae. **A.** Dorsal view of a female *Prionostemma* sp. 6. **B.** Lateral view of a male *Prionostemma* sp. 6. **C.** Dorsal view of a female *Prionostemma* sp. 7. **D.** Lateral view of a female *Prionostemma* sp. 7. **E.** Dorsal view of a male *Prionostemma vittatum*. **F.** Dorsal view of a male *Prionostemma vittatum.* Scale bars = 3 mm.

mens from each species that were collected from Trinidad revealed little or no intraspecific variation in penis morphology (Figs. 5F-L).

With respect to natural history, we collected individuals of both species from beneath palm fronds and logs (n = 114 for *C. granulata*, n = 22 for *P. inglei*). Several individuals of *C. granulata* stridulated in response to being held. The functional significance of this behavior is unclear, although it may be useful in defense as a means for startling a potential predator (Gnaspini and Hara 2007). We also observed that several adults retracted their legs and remained motionless for many seconds when disturbed. Prior studies have interpreted this behavior as thanatosis or death feigning (Chelini *et al.* 2009). We collected several, relatively late nymphs (n = 5) of *P. inglei*. In contrast to adults, nymphs possess elongate, pointed (rather than flattened) pedipalps.

Cranaidae

Recently, Pinto-da-Rocha and Bonaldo (2011) synonymized the two known species of cranaid harvestmen from Trinidad. The sexually dimorphic characters that had been used to distinguish between males were reinterpreted as differences between two male morphotypes, alpha and beta. Adult male *Phareicranaus calcariferus* vary in total body length from 9.4-11.2 mm (Townsend *et al*. 2009) and are the largest species of harvestman on Trinidad (Townsend *et al.* 2008a). On Tobago, we collected adults (Figs. 2A-D) and nymphs. Adult males are easily recognized on the basis of their enlarged chelicerae and the armature of femur-tibia IV (Fig. 2B). The distal end of the penis of *P. calcariferus* has a ventral plate with a slightly concave margin, and an arrow-like stylus with a folded glans (Figs. 5M-O). We compared the genitalia of 3-5 adults from each island, but did not observe intraspecific variation in penis morphology between individuals collected from Trinidad and Tobago (Figs. 5M-O). However, we observed variation in the dorsal coloration of adult males on Tobago. Adults from Trinidad and most individuals from Tobago generally have large yellow or white spots on the lateral margins of the dorsal scutum (Fig. 2D). However, a few adult males from Tobago lacked these spots (Fig. 2C).

In the field, we found cranaids (n = 35 adults) generally inactive during the day. They were most commonly observed occupying spaces beneath logs or within palm

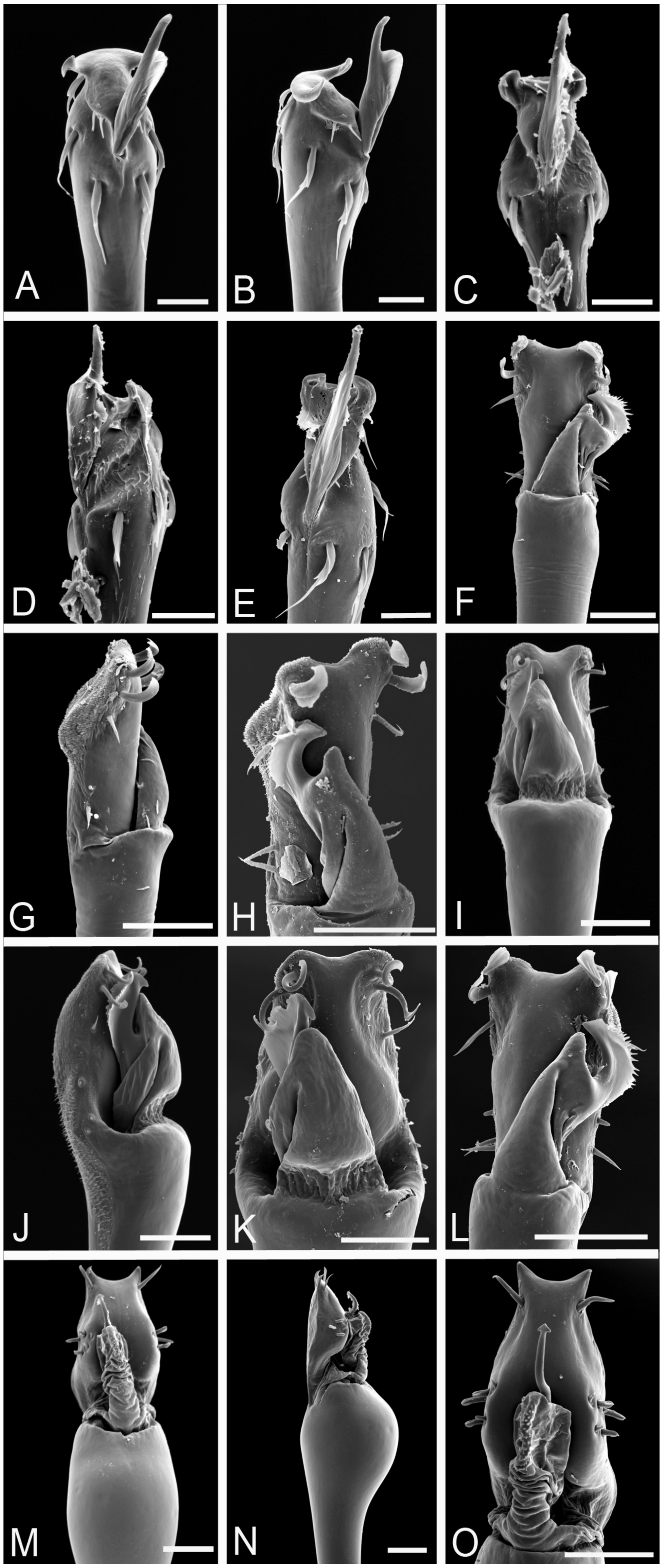

Fig. 5. SEM micrographs of the distal tip of the penis of select species of harvestmen. **A.** *Avima* sp. 1 (Agoristenidae) from Tobago, dorsal view. **B.** *Avima* sp. 1 (Agoristenidae) from Tobago, lateral view. **C.** *A. intermedia* from Tobago, dorsal view. **D.** *A. intermedia* from Tobago, lateral view. **E.** *A. leiobuniformis* from Trinidad, dorsal view. **F.** *Cynortula granulata* (Cosmetidae) from Tobago, dorsal view. **G.** *C. granulata* (Cosmetidae) from Tobago, lateral view. **H.** *C. granulata* from Trinidad, dorsal view. **I.** *Paecilaema inglei* (Cosmetidae) from Tobago, dorsal view. **J.** *P. inglei* (Cosmetidae) from Tobago, lateral view. **K.** *P. inglei* from Trinidad, dorsal view. **L.** *P. paucipustulatum* from Trinidad, dorsal view. **M.** *Phareicranaus calcariferus* (Cranaidae) from Tobago, dorsal view. **N.** *P. calcariferus* (Cranaidae) from Tobago, lateral view. **O.** *P. calcariferus* from Trinidad, dorsal view. Scale bars = 50 µm for A-E; 100 µm for F-O.

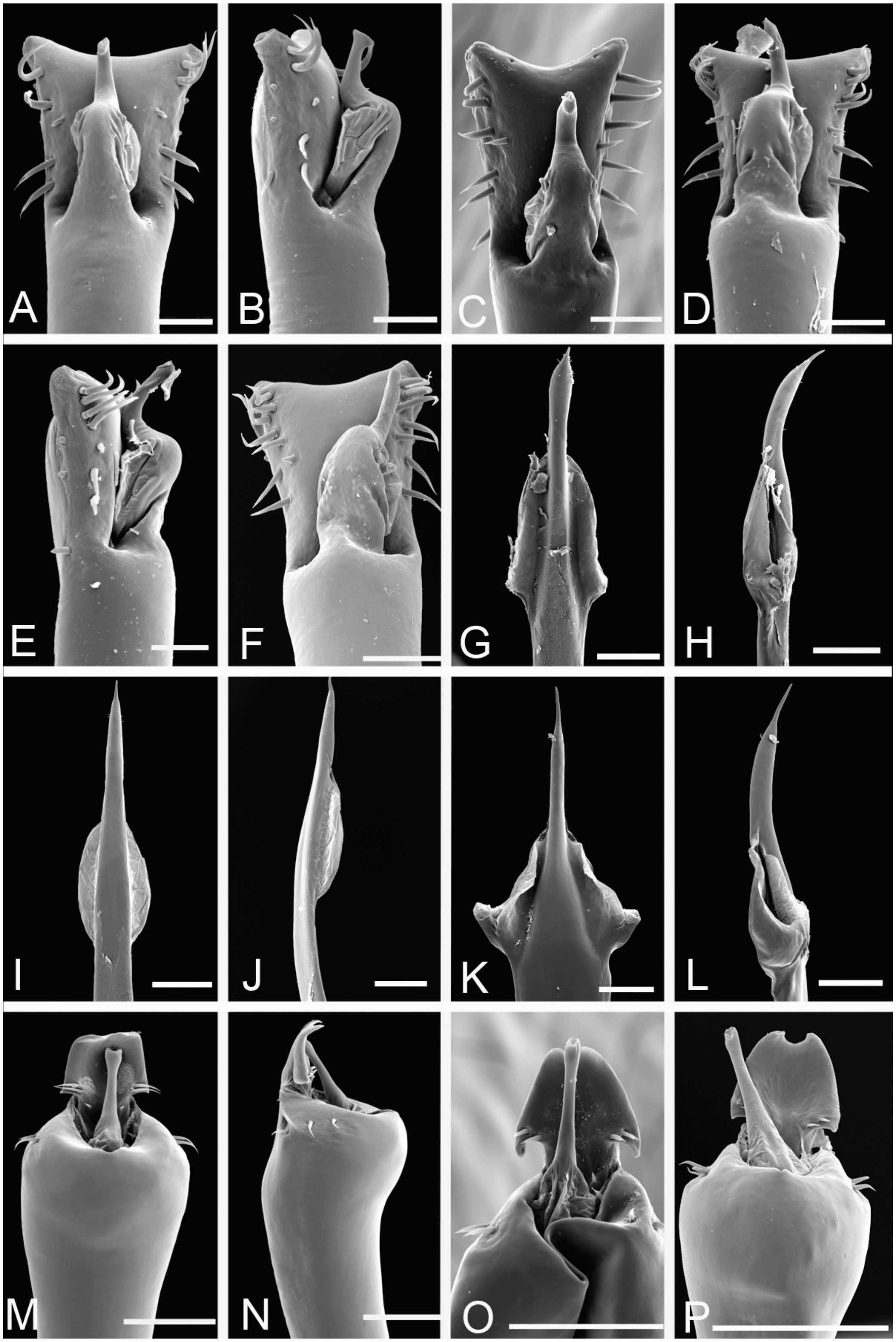

Fig. 6. SEM micrographs of the distal tip of the penis of select species of harvestmen. **A.** *Cranellus* sp. (Manaosbiidae) from Tobago, dorsal view. **B.** *Cranellus* sp. (Manaosbiidae) from Tobago, lateral view. **C.** *C. montgomeryi* from Trinidad, dorsal view. **D.** *Rhopalocranaus albilineatus* (Manaosbiidae) from Tobago, dorsal view. **E.** *R. albilineatus* (Manaosbiidae) from Tobago, lateral view. **F.** *R. albilineatus* from Trinidad, dorsal view. **G.** *Prionostemma* sp. 6 (Sclerosomatidae) from Tobago, dorsal view. **H.** *Prionostemma* sp. 6 (Sclerosomatidae) from Tobago, lateral view. **I.** *Prionostemma* sp. 7 from Tobago, dorsal view. **J.** *Prionostemma* sp. 7 from Tobago, lateral view. **K.** *P. vittatum* from Tobago, dorsal view. **L.** *P. vittatum* from Tobago, lateral view. **M.** *Stygnoplus biguttatus* (Stygnidae) from Tobago, dorsal view. **N.** *S. biguttatus* (Stygnidae) from Tobago, lateral view. **O.** *S. clavotibialis* from Trinidad, dorsal view. **P.** *S. tuberculatus* from Dominica, dorsal view. Scale bars = 50 µm for A-F; 150 µm for G-L; 100 µm for M-P.

frond sheaths. At night, however, we frequently discovered adults climbing the vegetation. With the exception of *Prionostemma* spp., *P. calcariferus* is probably the most arboreal harvestmen on Tobago. We also observed multiple instances of adults in close proximity to early and late nymphs (n = 40), presumably the adults actively defend eggs, larvae and nymphs (Machado and Warfel 2006; Hunter *et al.* 2007; Townsend *et al.* 2009; Townsend *et al.* 2011a).

Manaosbiidae

The males of *Cranellus* and *Rhopalocranaus* possess enlarged and fused basitarsi on leg I (Fig. 3A), features not exhibited by females. This dimorphism is common to most, but not all, taxa in the family (Kury 1997; Townsend *et al.* 2011b). These species differ markedly with respect to coloration. *Cranellus* sp. has a dark brown dorsum with lighter brown-yellow appendages (Figs. 2E-F). In contrast, *Rhopalocranaus albilineatus* has white or yellow lines on its dark brown dorsum and its dark brown legs are similar in color to the dorsum (Figs. 3A-B). The *Cranellus* sp. from Tobago differs from *C. montgomeryi* from the Northern Range in Trinidad in several respects, including leg coloration and dorsal armature. In general, the legs of *Cranellus* sp. are darker and have a more distinct pattern of darker mottling than those of *C. montgomeryi*. This species also has fewer small, granular tubercles on its dorsum. The penis of this species has one less marginal spine on each side of the ventral plate as well as a slightly more concave distal margin (Fig. 6A-B) than that of *C. montgomeryi* (Fig. 6C). Based upon an examination of multiple (3-5) individuals, we did not find any intraspecific variation in penis morphology between populations of *R. albilineatus* from Trinidad and Tobago (Figs. 6D-F).

Our field collections indicate that *R. albilineatus* is generally more abundant (n = 122 adults) than *Cranellus* sp. (n = 9) on Tobago. We also collected several late nymphs of *R. albilineatus* (n = 28) and *Cranellus* sp. (n = 5), indicating that both species were reproductively active prior to our sampling period. Individuals were most frequently captured from beneath logs, palm fronds and the leaf litter.

Sclerosomatidae

We collected three species of harvestmen from this family, including *Prionostemma vittatum,* and two unidentified *Prionostemma* spp. (species 6 and 7; these species differ from three unidentified species from Trinidad (Townsend *et al*. 2008a)). *Prionostemma vittatum* (Figs. 4E-F) differs from other species in having lightly colored coxae, with a dark eye mound, and two black lines on its dorsum. In Trinidad (Townsend *et al.* 2008a), it is one of the most common harvestmen, however, on Tobago, we only collected two adults.

Prionostemma sp. 6 is generally very dark (Figs. 4A-B). In the living condition, individuals of both sexes are bluish green. In ethanol, much of this coloration fades, however, if a specimen is allowed to air dry, small spots of blue or green become readily visible. To further investigate this unusual coloration, we examined an in-

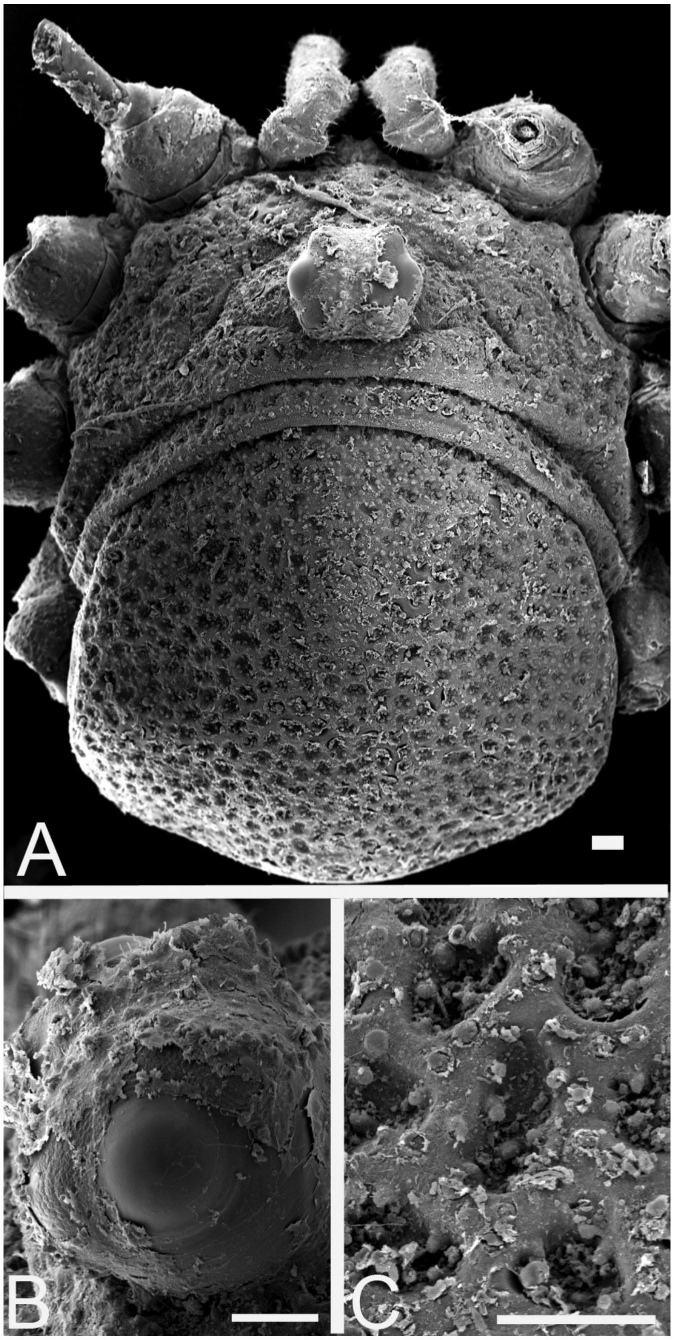

Fig. 7. SEM micrographs of the dorsal surfaces of an adult male *Prionostemma* sp. 6 revealing the distribution of an epizoic organism, presumably cyanobacteria. **A.** Dorsal habitus. **B.** Lateral view of eye mound. **C.** Pits on dorsal surface of opisthosoma. Scale bars = 100 µm.

dividual with SEM (Fig. 7). The dorsal surface of this specimen had a highly pitted morphology (Fig. 7A, C). The prosoma, opisthosoma, ocularium (Fig. 7B) and coxae were covered in a thin, irregular film that had a scattered distribution of small, rounded cellular structures. Removal of this film from several individuals and examination by light microscopy revealed that these cells were similar in size and shape to those of cyanobacteria, but were not distinctive. Machado and Vital (2001) identified epizoic cyanobacteria and liverworts from multiple specimens of Neotropical harvestmen in Brazil. Given the color and general morphology of the film present on this specimen, we hypothesize that these harvestmen host either cyanobacteria or an epizoic fungus. We collected 55 individuals of this species, every specimen was bluish green.

The second unidentified species (Figs. 4C-D) was also relatively common (n = 40 adults). This species had a dark patch on the lateral margins and posterior third of the dorsum, a dark prosoma and coxae, and a lighter ventral surface of the opisthosoma. With respect to reproductive morphology, the penises of sclerosomatid harvestmen feature a truncus with a terminal stylus (Tourinho 2007). Neotropical species in this family also often possess an alate portion with winglets (Figs. 6G-L). We observed interspecific variation in the relative size and shape of the winglets and the relative length of the stylus at the tip of the glans.

Sclerosomatid harvestmen are generally inactive during the day, occupying perches on leafy vegetation and on tree trunks and buttresses. After dark, they become more active and wander in the leaf litter, presumably in search of food and mates (Grether and Donaldson 2007; Donaldson and Grether 2007; Wade *et al.* 2011). We rarely captured individuals from beneath cover objects. We captured 12 early and late nymphs, but were unable to identify them to species.

Stygnidae

We collected multiple adult *Stygnoplus biguttatus* Pinto-da-Rocha 1997 (n = 9). Males possess relatively large chelicerae (Fig. 3C, E) in comparison to females (Fig. 3F). Femur-tibia IV of the male is also armed with large spines (Fig. 3D) that are absent on the female. Males from Tobago appear to possess relatively larger spines on leg IV in comparison with those from populations in Venezuela (Pinto-da-Rocha 1997). In *Stygnoplus*, the dorsum is also adorned with a single large spine between the separate eye mounds and there are paired, large spiniform tubercles on the posterior region of the opisthosoma (Figs. 3E-F). In *Stygnoplus biguttatus*, the relative size of the spine between the eyes is also sexually dimorphic (Figs. 3E-F). Penis morphology (Fig. 6M-P) consists of a truncus with a distal tip divided into a ventral plate and dorsal glans bearing the stylus (Pinto-da-Rocha 1997). In comparison to *S. clavotibialis* from Trinidad (Fig. 6O) and *S. tuberculatus* from Dominica (Fig. 6P), the ventral plate of the penis in this species (Fig. 6M) differs in shape with respect to both the distal margin and the proximal, lateral margins. In addition, the relative shape and size of the stylus exhibits interspecific variation.

With respect to natural history, individuals were collected from logs and the surfaces of tree buttresses, but were not found in the leaf litter. We rarely captured more than two individuals from the same area and did not observe any nymphs.

SUMMARY

Our field study provides the first insights into the biology of harvestmen from Tobago and further contributes to the study of their diversity and biogeography in the West Indies. Our data collectively increase the diversity of harvestmen occurring on Tobago from one to 11 species (Kury 2003). Owing to the limitations of our sampling method with respect to small leaf litter taxa and our limited number of sample sites, we were only able to confirm the occurrence of six families on Tobago (Table 1). A more thorough sampling approach involving pitfall traps and litter sifting is needed to determine if harvestmen from the families Kimulidae, Samoidae, Stygnommatidae and Zalmoxidae also occur on the island.

Our natural history observations for the harvestmen of Tobago are similar to those previously reported for species from Trinidad during the wet season (Townsend *et al.* 2008a). In general, our field observations indicate that most species are nocturnal and active in the leaf litter in forested habitats. In addition, the collection of nymphs indicates that several species are reproductively active during the later months of the dry season or the early portion of the wet season. As with populations of *Phareicranaus calcariferus* in Trinidad (Hunter *et al.* 2007; Townsend *et al.* 2009; Townsend *et al.* 2011a), we found adult *P. calcariferus* in close proximity to nymphs of several instars in Tobago. With the exception of this species, little is known about the behavior or reproductive biology of harvestmen from either Trinidad or Tobago. Future studies that investigate natural history and behavior as well as interactions between harvestmen and their predators, prey and parasites are needed for both wet and dry seasons.

With respect to reproductive anatomy, our study provides the first descriptions or SEM micrographs of penis morphology for several species of harvestmen from Tobago and Trinidad, especially for taxa described prior to the 1970s. Over the past several decades, characters based upon penis morphology have become critical elements in taxonomic studies (Acosta *et al.* 2007). Comparative studies of reproductive anatomy are also useful in examining intraspecific and interspecific variation among populations from different islands. In our study, we were able to confirm the presence of *Cynortula granulata*, *Paecilaema inglei* and *Rhopalocranaus albilineatus* on Tobago.

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Free-living Nematodes from a Natural Oil Seep at La Brea, Trinidad and Tobago

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ABSTRACT

The La Brea oil seep in Trinidad is reportedly one of the largest natural oil seeps in the world. As part of a larger environmental survey of this seepage site, the free-living marine nematodes of the meiofauna were studied. Samples were collected using 60 mm corers at 10 stations at the seep site, between Point Courbarill and Point Rouge west of the Trinidad Pitch Lake. The nematode fauna was represented by 16 families and 32 species. Five families: Chromadoridae, Comesomatidae, Linhomoeidae, Monohysteridae and Ethmolaimidae, comprised approximately 75% of the total abundance. The species diversity (H') was 3.09 with a range of 1.39 to 2.83 between stations. Given the uniqueness of this ecosystem, the average taxonomic distinctness index of biodiversity (Δ^+) was applied to the nematode data and comparisons were made with other locations in the UK and Chile. Taxonomic distinctness (Δ^+) values for La Brea was determined to be 73.28, with the lowest value at station 6 (64.81). Although nematodes are relatively abundant in the sediment samples from La Brea, their extremely low taxonomic distinctness is indicative of a stressed environment.

Key words: free-living marine nematodes, Trinidad and Tobago, natural oil seep.

INTRODUCTION

The La Brea oil seep, located between Point Courbarill and Point Rouge west of the Trinidad Pitch Lake (Fig. 1), had been documented since the early 1800's (Mallet 1802). Seepage at this site still occurs, though it is not as prolific as described in early reports. A steady stream of oil globules can be seen emerging at the surface of the water over an area of approximately 70-100 m^2. The La Brea seep has one of the highest seepage rates in the world with an estimated volume of 100 barrels per day per 1000 sq. miles metric (Johnson 1970; Wilson *et al.* 1979; Agard *et al.* 1993).

Various studies have examined macrofaunal species distribution at oil seeps and used various indices to assess the effects of long-term exposure to oil on these organisms (Spies and Davis 1979; Davis and Spies 1980; Giammona 1980; Montagna *et al.* 1987; Steichen *et al.* 1996). However, many of these (Shannon-Wiener, log normal distribution models) indices were only based on macrofaunal distributions (Platt and Lambshead 1985) and do not indicate whether these organisms exist in a stressed environment. These univariate methods typically have no defined scale, and they do not consider information on the relative distinctness of taxa (i.e., how closely or distantly species are related to each other). Only a few of these studies have also reported on nematode numbers, but have not identified nematode species.

Clarke and Warwick (1998) showed that the average taxonomic distinctness (Δ^+) has a number of desirable properties as a measure of biodiversity in the context of environmental impact assessment, notably its lack of dependence on sample size and sampling effort. This enables comparisons to be made between studies in which the sampling varies. This is not the case with most of the traditional species diversity measures which are very sample size dependent. Comparisons can also be made on the basis of taxonomic distinctness which has been found to decrease with increasing levels of environmental impacts (Warwick and Clarke 1998).

This paper provides a first report on nematodes from a natural oil seep at La Brea, Trinidad. It also uses taxonomic distinctness measures of nematodes to assess whether a natural oil seep is a stressed environment. Nematodes may serve as a good indicator of environmental quality because of their high abundance, high diversity and their intimate contact with pore water (Lambshead 1986; Bongers 1990; Kennedy and Jacoby 1999; Platt *et al.* 1984; Danovaro 2000).

MATERIALS AND METHODS

Sediment samples were collected at ten stations (Fig.1) using a hand-operated multiple corer which consisted of three 60 mL syringes mounted on a circular platform; a design that allowed for the easy removal and

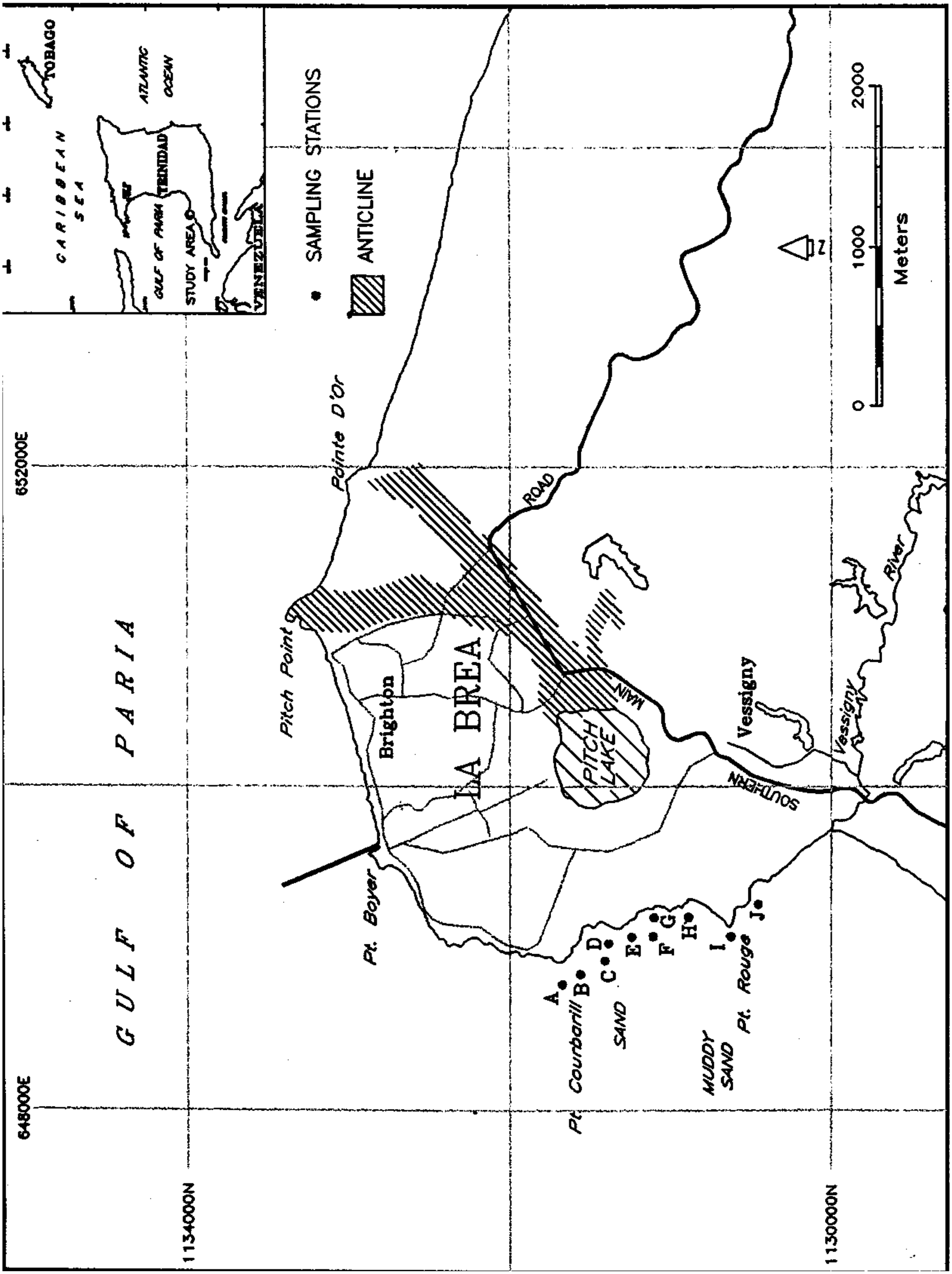

Fig. 1. La Brea Seep, showing the location of the sample stations.

replacement of syringes between sample stations. The tapered end of each syringe was removed, forming a hollow cylinder, the edge of which was sharpened to allow easy penetration into the sediment. Two small holes drilled at the top of each syringe allowed water to be displaced as the cylinders plunged into the sediment.

Sediment cores were placed in plastic bags, preserved in 10% formalin and taken back to the laboratory where they were individually washed through a 63 µm sieve. The meiofauna were separated by flotation using Ludox TM (Platt and Warwick 1983). Each of the samples was then washed and dehydrated for 24 h at 45°C in a 10% glycerol solution and mounted onto glass slides. Nematodes were counted and identified to genus, or species level where possible, using taxonomic keys by Platt and Warwick (1983, 1988).

Data Analysis

Shannon diversity indices (H') and average taxonomic distinctness (Δ^+) (Warwick and Clarke 1995, 1998, 2001) were calculated for nematode assemblages from all the sample stations. Average taxonomic distinctness (Δ^+) is a measure of the degree to which the species in a sample are related taxonomically to each other, and is the average path length between every pair of species traced through a taxonomic tree. From data consisting only of presence or absence of species (i.e. species lists), it is defined mathematically as,

$$\Delta^+ = \left[\sum \sum_{i<j} \omega_{ij}\right] / \left[s\left(s-1\right)/2\right]$$

where s is the number of species present, the double summation is over the set $\{i = l, \ldots., s; j = l, \ldots, s,$ such that $i < j\}$ and is the 'distinctness ω_{ij} weight' between species i and j. Equal step lengths are normally assumed between each level in the taxonomic hierarchy (species to genus, genus to family, etc.), and Clarke and Warwick (1998) suggest that they be standardised so that the distinctness of two species connected at the highest level (the taxonomically most distant pairing used in a batch of analyses) is set equal to 100. In the present case we have used the six taxonomic levels of species. The taxonomic distinctness determined for the La Brea seep was also compared with the values calculated for other polluted and unpolluted sites in the United Kingdom (Northumberland Coast and Tyne) and in Chile.

RESULTS

One hundred and forty-nine nematodes belonging to 16 families and comprised of 32 species were identified. Many of these appeared to be previously undescribed species (Warwick, pers. comm.). The nematode species list for the La Brea seep is shown in Table 1. Nematodes belonging to the family Chromadoridae were the most dominant, accounting for about 20% of the total number identified at the seep site, while the most dominant species was *Daptonema* sp.1. Five families - Chromadoridae, Comesomatidae, Linhomoeidae, Monohysteridae and Ethmolaimidae - comprised approximately 75% of the total abundance. Two families - Richtersiidae and Sphaerolaimidae - were previously reported as new records for Trinidad and Tobago (Gobin 2007). Nematode abundances were similar for all stations except for Station 6 where it was highest. Following Wieser's classification, four feeding groups of nematodes were identified. The epigrazers and deposit feeders accounted for 44% and 48% respectively of the total number of nematodes with the remainder (approx. 6%) consisting of predators and omnivores.

The species diversity (H') for all the stations at the La Brea seep was 3.09 with a range of 1.39 to 2.83 for the individual stations. Taxonomic distinctness (Δ^+) values for La Brea was determined to be 73.28, with the lowest value at Station 6 (64.81). When compared to values from different areas in the United Kingdom and Chile (Fig. 2), the value for the La Brea seep site was the lowest. The highest value of taxonomic distinctness for offshore soft sediments was reported in Chile (78.18), a relatively unpolluted site, while the most polluted site in the UK (Liverpool Bay) had a value of 74.67. The taxonomic distinctness value (73.28) for all the sites in La Brea were indeed lower than those reported from Chile and the United Kingdom (Fig. 2).

DISCUSSION

The present study provides a first list of free-living marine nematodes associated with a natural oil seep in Trinidad and Tobago. The nematode densities (149 per 114 cm^2) were higher than that reported for other species such as polychaetes (*Pararionospiso pinnata* 182 m^{-2}, *Nereris micromma* 182 m^{-2}) and the bivalve *Corbula caribea* (46 m^{-2}), at the La Brea seep. However, it was lower than that reported by Davis and Spies (1980) for Coal Oil Point, Santa Barbara (8.5 per core) and Steichen *et al.* (1996) reported higher nematode densities (229 per 78 cm^2) for the Isla Vista seep. Most such studies have focused on assemblages of organisms or total numbers, with few studies actually identifying the nematode species present.

The La Brea seep is biologically productive despite the high levels of hydrocarbon (26 - 200 µg g^{-1} chrysene equivalents) reported by Agard *et al.* (1988) who described the area as "contaminated". Under such conditions, it is expected organisms in that environment may

Table 1. Nematode (phylum Nematoda) families and species list for the La Brea oil seep coastal area. Family totals are in bold.

Family and Species	**No. of Individuals**
AXONOLAIMIDAE	
**Paraodontophora* sp. 1	7
CERANOMATIDAE	
Pselionema sp. 1	2
CHROMADORIDAE	
Ptycholaimellus sp. 1	5
**Innocuonema* sp. 1	12
**Graphonema* sp. 1	1
Chromadorid sp. 1	6
Chromadorid sp. 2	1
**Metachromadora* sp. 1	3
Hypodontolaimus sp. 1	2
COMESOMATIDAE	
Comesoma sp.1	10
Sabatieria sp. 1	8
**Dorylaimopsis* sp. 1	4
**Cervonema* sp. 1	1
CYATHOLAIMIDAE	
Paracanthonchus sp. 1	**1**
DESMODORIDAE	
Desmodora sp.1	**6**
DIPLOPELTIDAE	
**Campylaimus* sp. a	**1**
ENOPLIDAE	
**Mesacanthion* sp. a	**1**
ETHMOLAIMIDAE	
**Neotonchus* sp. 1	1
**Filitonchus* sp. 1	10
**Neotonchus* sp. 2	**1**
LINHOMOEIDAE	
**Terschellingia* sp. 1	15
**Terschellingia* sp. 2	6
**Terschellingia* sp. 3	2
**Terschellingia* sp. 4	1
MICROLAIMIDAE	
**Aponema* sp. 1	**4**
ONCHOLAIMIDAE	
Viscosia sp.1	**1**
OXYSTOMINIDAE	
Halalaimus sp. 1	**3**
*RICHTERSIIDAE	
**Richtersia* sp. 1	**9**
*SPHAEROLAIMIDAE	
**Sphaerolaimus* sp. 1	**2**
MONOHYSTERIDAE	
Daptonema sp. 1	17
Paramonohystera sp.1	2
Steineria sp. 1	3
Total nematodes	**148**

* - first records for Trinidad and Tobago

be negatively impacted. However, chronic exposure to hydrocarbons does not always appear to have a toxic effect on organisms as might be expected. Mohammed and Agard (2004) reported that *Corbula caribea* from the seep site had higher levels of NADPH-ferrihaemoprotein reductase when compared to organisms from other sites, which allowed them to tolerate the high levels of hydrocarbons at the seep. Within hydrocarbon-rich environments such as seeps, numerous oil-degrading bacteria have been identified which may utilize the hydrocarbons as a source of energy, and serves as a supplementary food source for meio- and macro-benthic organisms in shallow water (Spies and DesMarais 1983; Bauer *et al.* 1990). Although the oily layer over sediment may be directly responsible for the reduced abundances and diversity, this stress may be moderated by the nutritive benefits of abundant bacteria. Steichen *et al.* (1996) at Coal Oil Point found that of all the taxonomic groups studied, only nematode abundances were positively correlated with oil contamination. The direct toxic effects of oil or its by-products as well as the deleterious effects of increased sulfide levels generated by microbial activity may be responsible for this (Steichen *et al.* 1996).

Assessment of natural oil seeps have focused primarily on the diversity of species assemblages (Spies and DesMarais 1983; Bauer *et al.* 1990; Davis and Spies

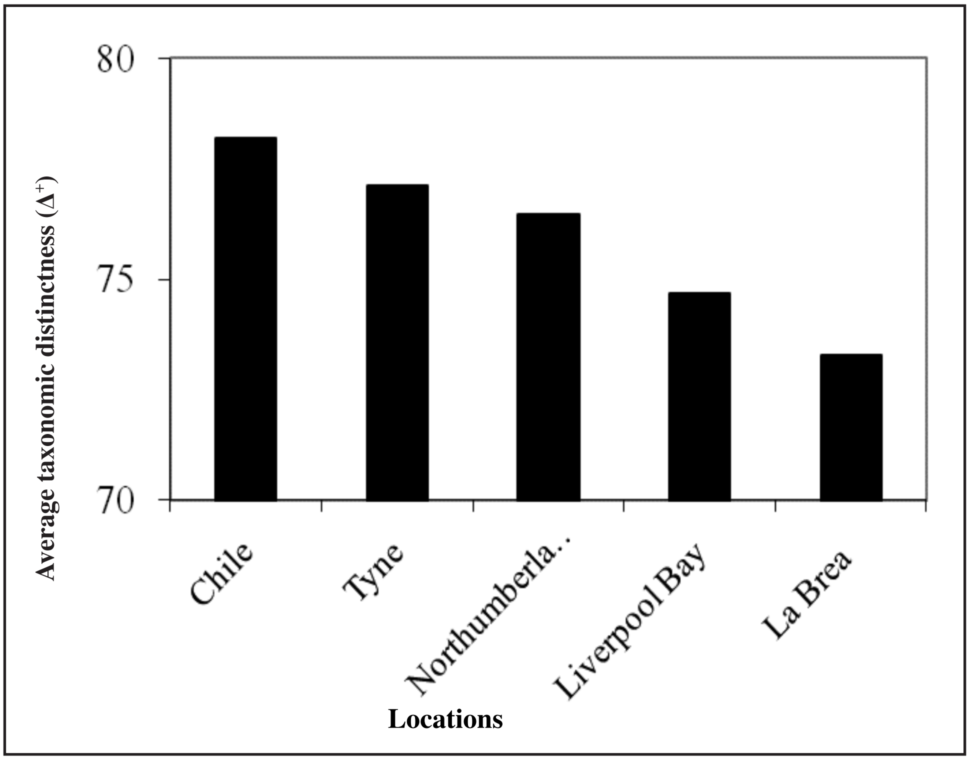

Fig. 2. Taxonomic distinctness (Δ^+) values for temperate (Tyne, Northumberland, Liverpool Bay - UK) and tropical (Chile, La Brea - Trinidad) soft sediment nematode communities.

1980; Montagna *et al.* 1987; Steichen *et al.* 1996) or hydrocarbon levels (Agard *et al.* 1988). However, these assessments give no real indication as to the extent of stress within these environments. Conventional Shannon diversity (H') index for the nematode assemblage from the La Brea seep yielded a value of 3.09, which was higher than the 1.69 - 1.71 reported by Spies and Davis (1979) for all the species recorded at Coal Oil Point, Santa Barbara. Though diversity indices for soft bottom sediments from the Caribbean are not available, nematodes of rocky substrates had a similar diversity index (2.60) (Gobin 1994). However, these values do not give a good indication as to the extent of environmental stress within the seep. These univariate indices show greater diversity when abundance is more evenly distributed among the species sampled, and when the number of species in a sample increases. They have no defined scale, which compromises comparison between studies; they vary naturally between habitats and within habitats over time and they do not consider information on the relative distinctness of taxa (i.e., how closely or distantly species are related to each other). Although nematodes are relatively abundant in the sediment samples from La Brea, their extremely low taxonomic distinctness is indicative of severe environmental stress. These values are the lowest recorded globally for any nematode assemblage from sublittoral habitats so far studied (Fig. 2).

Taxonomic distinctness (Δ^+) measures of the taxonomic spread of species in the assemblage and these observations add further weight to the utility of Δ^+ as a comparative measure of environmental stress. It is difficult to see any other way in which environmental stress at the community level of biological organisation could be measured on such a unified comparative scale. The data used for this comparison are by no means standardised or controlled in terms of the number of location, the core size etc., so that relative diversity measures based on the number of species would be unsuitable as a basis for comparisons.

The La Brea seep has the lowest Δ^+ value when compared to other sublittoral habitats (Fig. 2), which suggest that it is the most stressed of the sites. Northumberland is a relatively pristine mud and sandy mud area (Warwick and Buchanan 1970). The Tyne, a sewage sludge dumping ground, is a dispersive site where environmental impact on both meiobenthos and macrobenthos is relatively slight (Somerfield *et al.* 1993), while Liverpool Bay is a heavily industrialised and sewage polluted area (Somerfield *et al.* 1995). These observations add further weight to the utility of Δ^+ as a comparative measure of environmental stress.

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An Investigation into the *Amblyomma* Tick (Acari: Ixodidae) Infections of the Cane Toad (*Rhinella marina*) at Four Sites in Northern Trinidad

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ABSTRACT

Two species of tick are known to parasitize cane toads on Trinidad, *Amblyomma dissimile* and *Amblyomma rotundatum*. The focus of this study was to investigate differences in the levels of tick parasitism in cane toad populations at four sites in northern Trinidad representing different habitat types, the effect of physical host characteristics on tick loads and to determine the impact of ticks on cane toad health. Significant differences were found in tick loads between sites, possibly due to human disturbance and modification. Toad sex and condition index appear to be unrelated to tick load but wounds associated with previous tick attachment were found to be common and in two cases these wounds were seen to be secondarily infected by larva of a *Notochaeta* species (Diptera: Calliphoridae). Toad size had varying levels of significance dependent upon sample site. Ticks were found to preferentially attach to certain body regions of the host (dorsum and chin) thought to be due to exposure and submersion in water. Differences in attachment sites were also seen between tick instars, though tick sex showed no relationship. *A. dissimile* was the more common of the two tick species by a considerable amount.

Key words: *Rhinella marina, Amblyomma dissimile, Amblyomma rotundatum*, parasite impact, Trinidad.

INTRODUCTION

Rhinella marina [=*Chaunus* (*Bufo*) *marinus*] (Linnaeus 1758), also known as the cane, giant or marine toad, is native to tropical regions of the Americas (Burridge and Simmons 2003; Sutherst *et al*. 1995) including Trinidad and Tobago (Ragoo and Omah-Maharaj 2003). They are now common in many non-native habitats, like Australia (Sutherst *et al.* 1995), through deliberate introductions and are thought to be having a negative impact on native fauna (Lampo and DeLeo 1998; Urban *et al*. 2007).

Cane toads are parasitized by two species of tick on Trinidad: *Amblyomma dissimile* Koch, 1844 and *Amblyomma rotundatum* Koch, 1844 (Lampo and Bayliss 1996b). The use of these ticks, along with other parasites such as the nematode lungworm *Rhabdias pseudosphaerocephala* (Kelehear *et al.* 2011), to control cane toad numbers in non-native regions is currently being considered (Lampo and Bayliss 1996a; Smith *et al*. 2008). However, introducing exotic ticks into new regions is of high concern due to the possible spread of tick-borne disease (González-Acuña *et al*. 2005). As *A. dissimile* has been implicated as a vector for the rickettsial disease *Ehrlicia* (=*Cowdria) ruminatum* of ruminants (Jongejan 1992), and the cane toad as a reservoir for the spirochete *Leptospira interrogans* which can cause leptospirosis on Trinidad and Grenada (Oliver *et al*. 1993), detailed information on the infection, transmission and impacts of ticks on toads must be known before any action is taken.

A lot of work has been carried out on mainland South America (Lampo and Bayliss 1996b) but published data on the parasitic tick infections of native cane toad populations in Trinidad is lacking. The aims of this project were to address the following questions: are there different rates of tick infection on cane toads at different locations; do the tick infections vary with the sex or size of the host; do tick loads have an impact on the health of cane toads; and finally, are tick loads clustered or evenly distributed across the host's body and does this vary between the three tick instars or according to the different species of tick?

METHODS

Sample sites

Four sample sites were used in this study, chosen for abundant cane toad populations and differing habitat:

1. Lopinot Stream: Natural mountain stream bordered by rainforest on one side and a recreational lawn and cemetery on the other (10.692575°N, 61.32175°W).
2. Las Cuevas: On the northern coast, largely undisturbed area. This site has a brackish river, rainforest and a sandy beach located close to the sea (within 100 m) (10.777894°N, 61.400562°W).
3. Simla: This site is in the Northern Range surrounded by rainforest with a maintained lawn and several man-made ponds (10.691868°N, 61.289282°W).
4. University of the West Indies Trinidad Campus (UWI): In the urban area of St. Augustine, this site is highly modified and maintained with grass fields, drainage ditches and a large artificial pond (10.63914°N, 61.395854°W).

Toad collection and inspection for ticks

Main investigation

Each site was sampled four times with 6-8 days between visits. On each trip, 10 toads were captured (first encountered) by hand between 1900-2100 h. These toads were taken to UWI, assigned a number and their snout to vent length (SVL; to the nearest 0.1cm) and weight (g) measured. The toads were sexed using the morphological characters in Narayan *et al*. (2008) (dorsal skin texture and colour, cream dorsal margin stripe and vocal sac openings) and photographs of the head, dorsal and ventral surfaces were taken to provide a record for recapture identification; toe-clipping was considered ethically unsound following May (2004). As reinfection rates and natural tick turnaround was unknown, all data from recaptured toads were excluded from the analysis.

Toads were examined for ticks (Fig. 1) and the number found on each of five predefined body regions (head, chin, legs, dorsum and venter) recorded. All ticks were removed and preserved in 95% ethanol and any sores/wounds/ulcers thought to be associated with previous tick attachment were also noted. Toads were returned to their original sample site within 24 hours.

Tick instar (1-larva; 2-nymph; 3-adult), sex (adults only) and species (adults only) were identified using a binocular microscope and published keys (Keirans and Durden 1998; Robinson 1926). No male *A. rotundatum* were expected as this species is regarded as parthenogenetic, although three males have been reported (Labruna *et al*. 2005).

Distribution of ticks on the host body

In order to investigate differences in attachment site between tick sexes, species and instars, clearly infected toads were collected at Lopinot, Las Cuevas and Simla (UWI was excluded due to low infection levels). These toads were captured after the study described above due to the non-random nature of their sampling. The final sample comprised nine parasitized toads per site. These were treated the same as the toads in the above study except the ticks removed from each body region were preserved separately.

Fig. 1. Image showing an engorged female tick (circled in red) attached to the chin of a cane toad.

Condition index (measure of health)

The condition index (CI) can be used as an indicator of the toad's health and was compared to tick load to investigate any correlation between the two factors. Although CI cannot be fully accounted for by tick parasitism, it has been previously used to investigate their impact on host health (Smith *et al*. 2008). CI was measured using the following equation from Eggert and Guyetant (2003):

$$CI = \frac{\text{weight (g)}}{SVL^3\text{(cm)}} \times 100$$

Population estimates

Host population size may help explain any differences in tick infection rates between sites. For this, photographs were used to identify toad recaptures. Population estimates were made using the Schnabel mark recapture equation (Sutherland 1996):

$$N= \frac{\sum(M_t C_t)}{\sum R_t+1}$$

C_t= Total number of individuals caught in sample t, R_t= number of individuals already marked (recaptures) when caught in sample t , M_t= number of marked animals in the population just before the t^{th} sample is taken.

RESULTS

Sample size

For each site 40 toads were sampled for the main investigation (160 in total). However, with the removal of recaptures the final sample sizes for each site were: Lopinot - 35; Las Cuevas - 37; Simla - 28; UWI - 36 (a total of 136). All three tick instars as well as adults of both species (*A. dissimile* and *A. rotundatum*) were found (species was only able to be determined in adults, instar 3); no male *A. rotundatum* were seen as expected. In total, 878 ticks were recovered: 445 were instar 1; 274 instar 2; 93 male *A. dissimile*; 49 female *A. dissimile*; 17 *A. rotundatum* (female).

For the *distribution of ticks on the host body* aspect of the study, nine toads were sampled from each of the three sites used, 27 in total (none of which were recaptures). From these toads, 293 ticks were removed: 122 were instar 1; 98 instar 2; 44 male *A. dissimile*; 24 female *A. dissimile*; five *A. rotundatum* (female).

Effect of site on tick load

Mean tick loads differed between sites (Fig. 2), especially Lopinot (7.97 ± 1.2 [standard error, SE] ticks per toad; n=35) and UWI (2.61 ± 1.5 [SE] ticks per toad; n=36) which showed the highest and lowest mean tick loads respectively. Both showed a large variation; as well as higher mean infections. Lopinot had a few individuals which were highly parasitized and UWI had the highest proportion of individuals with no ticks (55%). Las Cuevas had 6.95 ± 0.9 [SE] ticks per toad (n=37) and Simla 4.00 ± 0.9 [SE] ticks per toad (n=28). Both showed small variation suggesting some level of consistency in tick loads.

A Log (x+1) transformation was used on the data, chosen as the observational data (tick loads) contained zero values (Zar 1999), and a one way ANOVA (*aov*) performed. This showed that tick load was significantly affected by sample site (*aov*: $F_{(3,132)}=19.15$, $p<0.00001$). A factor reduction process was then used to see which sites differed significantly. The boxplot (Fig. 2) indicated that most of the variance was captured within UWI, with this site excluded, and this time using a square root transformation, a significant difference was again seen (*aov*: $F_{(2,96)}=8.426$, $p<0.00001$). Excluding the next lowest, Simla, and just looking at Lopinot and Las Cuevas, we found no significant effect (*aov*: $F_{(1,70)}=0.41$, $p>1$). A comparison of Simla and UWI (using the log function) revealed a reduced but still significant effect (*aov*: $F_{(1,62)}=6.448$, $p=0.05$). Therefore all sites, except Lopinot and Las Cuevas, show a significant difference in tick load.

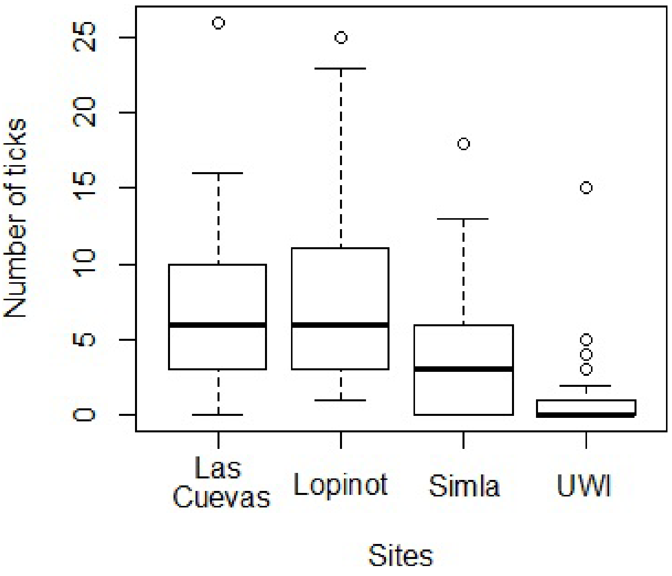

Fig. 2. Box and whisker plot showing the tick loads found at the four sample sites. One UWI sample (U075, tick n=52) has been omitted due to its outlying effect compressing the rest of the graph.

Large differences in toad population size were seen between the sites. Las Cuevas had the highest population (150), then UWI (120), Lopinot (100) and finally Simla (46). Recaptures were uncommon at all sites except Simla, the only site to show recaptures on all samples after the first. No minimum recapture number was indicated as necessary for this method; however, due to low recapture levels a dedicated population estimate may provide more insight and support. The accuracy of the recapture data is considered good with doubt about identifications in less than 3% of the sample. Although no definitive work on the uniqueness/consistency in the external features of cane toads could be found, if the toad's sex, markings and morphometric data (SVL and weight) corresponded to one captured on a previous sample at that site, it was marked as a recapture with confidence.

Relationships between the sex, weight and SVL of toads and tick loads

No significant difference was seen in the mean tick loads between male and female toads when using a t test (t=-1.77, df=134, P=0.078). The data also showed no significant relationships between toad weights and tick loads across the whole sample (General Linear Model [GLM]: $F_{(1,135)}=0.02$, P=0.889), but did show a significant positive relationship at both Lopinot (GLM: $F_{(1,34)}=4.95$, P=0.033) and Las Cuevas (GLM: $F_{(1,36)}=5.23$, P=0.028). Likewise, SVL showed no relationship with tick loads across the whole sample (GLM: $F_{(1,135)}=0.05$, P=0.826), but did have a significant positive relationship with tick load at Lopinot (GLM: $F_{(1,34)}=5.49$, P=0.025) and Las Cuevas (GLM: $F_{(1,36)}=5.39$, P=0.026).

Relationship between tick load and CI

CI appeared to be lower in infected males (CI: 0.0111 ± 0.0002 [SE]; n=17) compared to uninfected males (CI: 0.0115 ± 0.0004[SE]; n=67), whereas infected females appeared to have a higher CI (CI: 0.0118 ± 0.0003 [SE]; n=36) than uninfected females (CI: 0.0116 ± 0.0004 [SE]; n=16). However, these differences in CI were not significant in either males (GLM: $F_{(1,83)}=0.13$, P=0.718; n=84), females (GLM: $F_{(1,51)}=0.00$, P=0.980; n=52) or the population as a whole (GLM: $F_{(1,135)}=0.37$, P=0.547; CI: 0.0114 ± 0.0001[SE]; n=136). Although CI showed no significant relationship to tick load, 29% of the sampled toads had open wounds or sores/ulcers associated with previous tick attachment sites; in two of these cases toads had been secondarily infected by Dipteran larvae which were living under the host's skin.

Distribution of ticks on the host body

The distribution of ticks on the host body was found to be non-random and highly dependent upon body region (GLM: $F_{(1,143)}$=6.25, P=0.002). Overall a higher than expected percentage of ticks were found on the chin (651% of expected value (EV) [based on tick load, percentage body area of region and random distribution]) and dorsum (138%[EV]), and a lower than expected percentage on the legs (57%[EV]) and venter (11%[EV]). Head results varied by site but overall were higher than expected (194%[EV]).

The distribution of instars on the host was not entirely random. Significant differences were seen in instar attachment to both the dorsal (GLM: $F_{(2, 45)}$=3.29, P=0.047) and chin (GLM: $F_{(2, 42)}$=3.43, P=0.034) regions. Instar 1 was found to have a greater attachment on both the chin and dorsal surfaces, instar 2 (n=98) had a higher than expected attachment on just the dorsal surface and instar 3 (n=73) showed a significant lack of attachment to the dorsal region. Instar distribution on the head (GLM: $F_{(2, 17)}$=1.00, P=0.391), venter (GLM: $F_{(2, 17)}$=1.00, P=0.391) and legs (GLM: $F_{(2, 21)}$=1.74, P=0.203) was found to be not significantly different to random.

Within the sampled *A. dissimile,* no significant difference in attachment site was seen between sexes (GLM: $F_{(4, 52)}$=0.18, P=0.945). Both sexes of *A. dissimile* were found on just 37% of the toads with only 57% of female ticks found on the same regions as males and 37% of males found on the same regions as females; however, this reduced sample was too low (n=45) to determine any significant relationships.

DISCUSSION

Effect of site on tick load

The significant differences seen in tick loads between the four sites studied may be due to the level of human modification at each site as disturbance levels can have a serious impact on tick larval populations (Stein *et al*. 2008). Although all four sites are visited regularly by humans, both Las Cuevas and Lopinot are used for recreational purposes and are not highly modified. Simla, which shows lower tick levels, can be considered highly disturbed due to being an active research centre with year-round occupation. UWI is located in an urbanised area and is maintained to high standards for human aesthetics. This means that the vegetation required by ticks (Bermudez *et al*. 2010) to avoid desiccation, predation and excessive moisture (Stein *et al*. 2008) is less available, potentially making the habitat at UWI less suitable. The possibility of alternative hosts at sites of lower infection levels (UWI) was not investigated in this study as cane toads (along with iguanas) are considered the studied tick's primary host (Lampo *et al*. 1998). However, both *A. dissimile* and *A. rotundatum* are known to infect amphibians and reptiles other than cane toads (Lampo *et al*. 1998; Keirans and Oliver 1993) and juvenile instars have been found on mammals and birds, though this is rare (Robinson 1926). Though not considered significant, the effect of alternative hosts may warrant further investigation.

An explanation for the major differences in estimated cane toad populations between sites is offered by Hagman and Shine (2006) who found that open spawning sites with gradually sloping muddy banks were better for cane toad reproduction; this would make Lopinot and Las Cuevas the better spawning sites explaining their higher populations. However, cane toads are known to be highly opportunistic in spawning, utilising many locations such as drainage ditches (Murphy 1997), making this explanation less likely. When looking at Las Cuevas, Lopinot and Simla, tick parasitism may be, at least partly, population dependent as the greater populations of Lopinot and Las Cuevas had higher mean tick loads than Simla. This does not hold for UWI which had the second highest population estimate but the lowest mean infection load. However, as discussed above, the habitat at UWI was possibly not ideal for tick survival and transmission.

Effect of toad sex, weight and SVL on tick loads

The lack of a significant difference in tick loads between male and female cane toads concurs with research conducted by Lampo and Bayliss (1996b). However, a preliminary study (Crocker 2009) did find a significant difference in the tick loads of male and female cane toads (higher for males), so this perhaps requires further study.

Lampo and Bayliss (1996b) found a positive relationship between toad size and tick load up to a toad SVL of 140 mm, declining thereafter. This was only partially found in this study. Only two out of four study sites showed a significant positive relationship between toad size and tick load despite both of these increasing the available surface area for attachment on the host. The data for SVL and weight are conflicting in this study with half the sample sites showing a positive correlation with tick load and half no correlation, indicating the need for further study.

Effects of tick load on CI and other aspects of toad health

No significant relationship was seen between toad CI and tick load in the sampled population. Infestations were possibly not high enough, as the highest mean tick load (Lopinot) was only 7.97 ± 1.2 and the highest infestation 105 ticks. However, these are comparable to tick loads found by Lampo and Bayliss (1996b) in northern Venezuela and northern Brazil (an average of 2.48 ticks per toad and as many as 146 ticks on a single toad) who did find a significant decrease in toad condition index with increasing tick load. This shows a need to more extensively sample the cane toad population on Trinidad. If the results presented here are confirmed by future work, it may indicate a difference between the mainland South American and the Trinidadian cane toad population's response to tick parasitism.

Although the CI appeared unrelated to tick load, other factors were noted during this study. Open wounds or sores/ulcers associated with tick attachment sites, which are known to attract parasites such as screwworms (Fig. 3) or become secondarily infected by bacterial pathogens (Keirans and Durden 1998), were found to be common (29% of the sample). In two cases during this study, toads were found to have *Notochaeta* maggots (Diptera: Calliphoridae) underneath their skin having used what appeared to be previous tick attachment sites to gain access to the host's body. This has been seen in other anurans (Bolek and Janovy 2004) but no examples of it occurring in cane toads could be found.

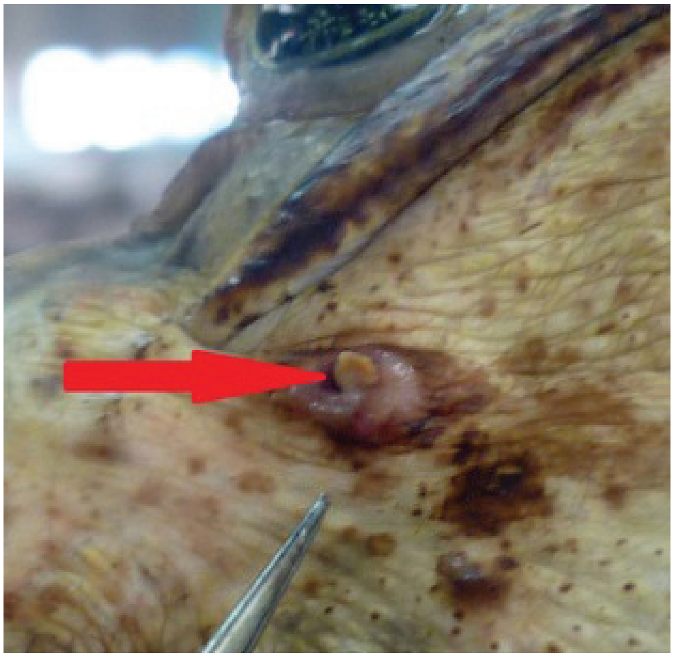

Fig. 3. The red arrow points to an example of the wounds caused by previous tick attachment; the cream/yellow object in the centre of the wound is a maggot emerging from under the host's skin; *Notochaeta* sp. (Diptera: Calliphoridae).

This study found no evidence to support the use of ticks to control cane toad numbers. However, as Smith *et al*. (2008) found data suggesting ticks' role in controlling *Chaunus schneideri* numbers, clearly more research must be done and it is these secondary infections we think should be the focus of this research.

Distribution of ticks on the host body

Tick distribution on the host was found to be highly aggregated on certain body regions with clustering on the dorsum, chin and (to a lesser extent) the head, with fewer seen on the legs and venter. This is similar to an *A. rotundatum* distribution found by Pontes *et al*. (2009) on snakes with greater attachment to the head and dorsum compared to the venter. The distribution seen in these two studies is possibly due to the fact that both snakes and cane toads drag their ventral surface on the ground as they move, preventing attachment as ticks tend to select areas of high feeding efficiency and minimal disturbance (Andrews and Petney 1981). However, Lampo and Bayliss (1996b) found no preference for tick attachment site on cane toads. An alternative explanation for the distribution seen in this study may be that tick attachment is not based on disturbance, but on host behaviour. Cane toads spend a lot of time partially submerged in the water and, as ticks are terrestrial parasites not adapted for an aquatic lifestyle (Pontes *et al*. 2009), this may explain their distribution. This is supported by Oliver *et al.* (1993) who found that when attached to submerged regions of the southern toad (*Bufo terrestris*), ticks would migrate across the host body to non-submerged locations. As this study was conducted during the rainy season when more frequent, and deeper, pools of water are available, this may help explain the observed avoidance of frequently submerged attachment sites by ticks.

There was a significant difference in attachment between tick instars on both the chin and dorsal surfaces. The reason for this is unknown as all seem to require the same thing, a blood meal. One possible explanation is the thickness of the cane toad's skin in relation to the length of the instars' mouthparts. Schwinger, Zanger and Greven (2001) found a significant difference between the cane toads' mean ventral, dorsal and lateral skin thickness (greatest on the dorsal, then lateral skin and thinnest on the venter) and Brown and Knapp (1980) found that instar 2 *Amblyomma americium* mouthparts penetrated 2.5x deeper than instar 1; though not reported, it is likely there is a further increase between instars 2 and 3. Also on warty regions, skin thickness will vary between thicker and thinner regions. This is unlikely to explain the variation seen here as specimens of all instars were found on all body regions and instars 1 and 2 had proportionally higher attachment rates than instar 3 on the dorsal surface, despite the greater skin thickness. Clearly other factors must be influencing tick instar distribution.

Instar size and disturbance/exposure to damage may help explain the distribution of ticks on the host. Instar 1 ticks (the most common instar found) from the same clutch are known to aggregate on a single host (Lampo and Bayliss 1996b) which may explain their clustered distribution. Little research has been done in this area and experimental work could be carried out to investigate the differences in attachment sites seen in this study and whether or not this represents a real difference in instar attachment site preference.

No significant differences were found in male and female *A. dissimile* attachment, most likely due to the fact that ticks mate whilst on the host (Jongejan and Uilenberg 2004) and both must avoid disturbance; females must feed to engorgement for egg production whereas males persist on the host in order to mate with multiple females (Drew and Samuel 1989; Jongejan and Uilenberg 2004).

A. dissimile was found to be a more common ectoparasite of cane toads at the four sites studied than *A. rotundatum*. The reason for this is unknown as they have a sympatric distribution, though *A. dissimile* is known to favour higher temperatures (Pontes *et al*. 2009), and both are a common parasite of the cane toad (Burridge and Simmons 2003). This could be studied further, including the effect of interspecific tick competition and ecological factors such as temperature, humidity and pH.

Tick specimens collected from this research have been added to the Hunterian Museum Collection, University of Glasgow (GLAHM: Entry Number 858) and a proportion sent to the University of the West Indies Zoology Museum (UWIZM), St. Augustine, Trinidad.

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NATURE NOTES

Corybantes mathani (Oberthür) (Lepidoptera: Castniidae), an Addition to the Insect Fauna of Trinidad, West Indies, and a Probable Oviposition on Moriche, *Mauritia flexuosa* (Arecaceae)

Castniidae is a family of large to very large moths, which mostly fly by day and can be brightly coloured. The Neotropical Castniidae comprises 87 described species in 33 genera (Vinciguerra *et al*. 2011). González and Cock (2004) provide a synopsis of the family in Trinidad and Tobago, reporting 11 species, originally included in nine genera, but now known to be only eight genera, since *Castniomera* Houlbert has been made a synonym of *Telchin* Hübner (Moraes and Duarte 2009). The genus *Corybantes* (Hübner) was not amongst those known from Trinidad and Tobago.

Corybantes mathani (Figs. 1, 2) is a rare species found in the Amazon and Orinoco Basins (Houlbert 1918; González 1999). Most known specimens are from Peru, Brazil, French Guyana and Venezuela (Houlbert 1918; Moss 1945; González 1999). This is the first record from Trinidad. The forewing ground colour is brown with an irregular transverse band that extends from the mid-costa to the anal angle. Hindwing ground colour is also brown and there is a prominent postdiscal spotted band near the margin. The abdomen is slightly longer than the anal margin of the hindwings. There is some sexual dimorphism shown by the size, subtle differences in shading of the forewings, as well as enlargement of spots that form the hindwing postdiscal band in females (Fig. 1).

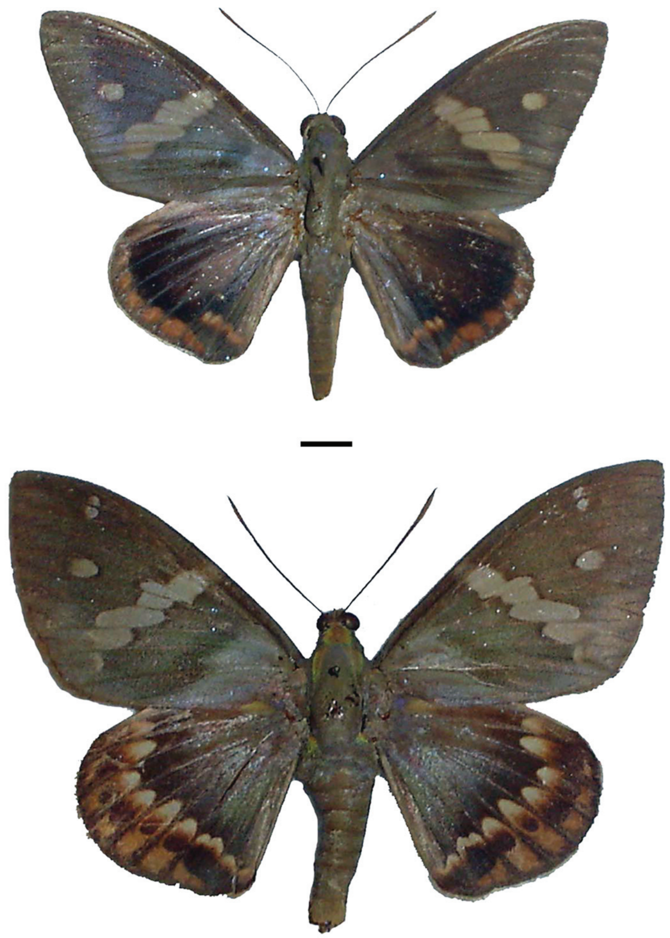

Fig. 1. Adult *Corybantes mathani* from Puerto Ayacucho, Amazonas State, Venezuela. **Top:** male; **Bottom:** female. Scale bar = 10 mm.

In Brazil, *C. mathani* is known to fly in February and October, and Venezuelan specimens have been collected in March to May and November (González 1999), thus it appears to be a bivoltine species. It flies from 0900-1200 h, at least one specimen is known to have emerged at 1500 h in the state of Pará, Brazil (Moss 1945; González 1999), while a freshly emerged couple was collected at 1815 h in March, 2006 in Puerto Ayacucho, Amazonas State, Venezuela (R. and R. Mattei, pers. comm. 2011). The caterpillars of other castniids are known to feed internally on a variety of monocotyledonous plants including sugar cane, *Heliconia* spp., bananas, bromeliads, orchids and palms (Moss 1945; González and Cock 2004). Based on circumstantial evidence, Moss (1945) suspected that the host of *C. mathani* could be the spiny palm *Acrocomia aculeata* (Arecaceae) or possibly a lily (Liliaceae), but he could find no proof of the latter when he examined putative food plants (Moss 1945). Most known Venezuelan specimens of *C. mathani* have been collected in the vicinity of either tall trees covered with bromeliads (González 1999) and orchids, or several species of palm trees (R. and R. Mattei, pers. comm. 2011).

Moriche palm *Mauritia flexuosa* is widespread in northern South America, east of the Andes, reaching Trinidad (Henderson *et al*. 1995). It is associated with periodically inundated lowlands in Trinidad, and the largest populations are in the Aripo Savannas – Long Stretch area and Nariva Swamp – with scattered populations in the south-west peninsular (Comeau *et al*. 2003). The branching inflorescences are very large and woody, and individual moriche palms bear either male flowers or female flowers, but not both (Henderson *et al*. 1995; Comeau *et al*. 2003). Each inflorescence consists of a central, primary branch or rachis about 2 m long, which supports two rows of pendulous flowering secondary branches more than 1m long (Fig. 3). In the male inflorescence, these branches consist of a long series of small tertiary branches, each bract on the secondary branch enclosing the base of a densely packed tertiary branch of male flowers and the base of the next bract (Fig. 4).

During a visit to the Aripo Savannas, Trinidad on 15 October, 2011, a rather worn female of *Corybantes mathani* (Oberthür) was seen and photographed by MJWC on a moriche palm *Mauritia flexuosa* (Arecaceae) (Fig. 2). The palm was in the KP Quarry section of Aripo Savannas (N10°36.352, W61°12.384) and was rather isolated from the main stands of moriche in that area, and the only one flowering for at least 100 m in all directions.

Fig. 2. Adult female *Corybantes mathani,* at rest on dead male inflorescence of moriche palm *Mauritia flexuosa*, Aripo Savannas, 15 October, 2011. **Top:** at 1123 h with head up; **Bottom:** at 1127 h with head down.

The palm (Fig. 3) was about 10 m tall at the crown, and had several young male inflorescences not yet releasing pollen and several old male inflorescences that were dead, dried and hard. The moth was first seen flying around the base of one of the oldest inflorescences, after which she was kept under observation using binoculars while she rested near the base of one of the most basal secondary branches of the inflorescence (Fig. 3 arrow), moving position slightly at least once during the period she was under observation. She stayed at rest on the inflorescence for a little more than five minutes, based on the time of photographs recorded by the camera from 1122 h to 1127 h. When first observed (Fig. 2 above), she was resting head up on the secondary branch, but then moved slightly upwards and rested with the head downwards (Fig. 2 below). As we prepared to place a bamboo ladder against the palm to sample the inflorescences, the moth flew off at about 5 m height with what seemed a relatively slow wing beat compared to that of Trinidad's commonest castniid, *Telchin licus* (Drury) (M.J.W. Cock, unpublished observations).

Fig. 3. The crown of the moriche palm *Mauritia flexuosa* showing the male inflorescences and lower right, the dead male inflorescence on which the *Corybantes mathani* was photographed (indicated by arrow), Aripo Savannas, 15 October, 2011.

As she was clearly in rather worn condition (Fig. 2), this female of *C. mathani* could not have been newly emerged. The behaviour on a dead male inflorescence for five minutes, suggests that the female may have been ovipositing or investigating possible oviposition sites. The obvious place to oviposit on the secondary inflorescence branch would be under the bracts (Fig. 4); the initial head up position of the moth (Fig. 2 above) would not be suitable for this, but the position subsequently adopted (Fig. 2 below) would be. The location near the crown of the palm resting at the bottom part of a basal secondary inflorescence branch may be significant. The hatching caterpillar could bore into the branch and move from there into the rachis, and either develop there or continue to the crown of the palm. The photographs were not carefully examined at the time, nor this chain of reasoning developed, so that when we subsequently sampled the inflorescences of this palm, the basal secondary branch on which the *C. mathani* female had been resting was not included in our sample, and so could not be checked for ova. Noting also the close overlap of the geographical ranges of *C. mathani* and *M. flexuosa* in South America, we consider it rather likely that *M. flexuosa* is a food plant of *C. mathani*.

Fig. 4. Detail of part of the dead, dried, male inflorescence of the moriche palm *Mauritia flexuosa* shown in Fig. 3. Within the bract around the base of each tertiary branch and the next bract would seem the obvious place for oviposition by *Corybantes mathani*. The tertiary branches are about 4-5 cm long.

Both Aripo Savannas and Nariva Swamp, the two main habitats for moriche palm in Trinidad, are important conservation areas, and *C. mathani* is a rare species now associated with the former, but likely to occur in the latter.

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On the Biology of *Memphis pithyusa morena* (Lepidoptera: Nymphalidae) in Trinidad, West Indies

De Gannes (2011) reported an unusual outbreak of *Memphis pithyusa* (R. Felder) (Nymphalidae), the southern blue leaf shoemaker butterfly (Barcant 1970), at Point Gourde in August 2010. Examination of further material shows that the Trinidad population belongs to subspecies *Memphis pithyusa morena* (Hall), described from French Guiana and reported from the Amazon north to Mexico (Comstock 1961). De Gannes (2011) found the food plant at Point Gourde to be *Croton niveus* (Euphorbiaceae) and reared out many specimens.

On a return visit to Point Gourde, 16 October, 2011, the authors saw no adult *M. pithyusa*, and although several leaf rolls were found, all were empty except one. This one contained a final instar caterpillar, which is documented here.

The leaf roll shelter (Fig. 1) was made by making a cut from the edge of the leaf diagonally to close to the mid-rib. The distal flap of the leaf was rolled to make a tube, wider basally, but apparently open at the distal end. The edge of the leaf flap was attached to the upper surface of the leaf, edge on, with silk, so that the shelter was a single thickness, not a spiral. The shelter was thickly lined with white silk so that the distal, narrow end was closed, and the only access was through the basal end which was blocked by the head of the caterpillar within (Fig. 2).

Fig. 1. Leaf roll of *Memphis pithyusa morena in situ,* on *Croton niveus*, Point Gourde, 16 October, 2011, C. De Gannes and M.J.W. Cock, MJWC Ref. 11/42.

The final instar caterpillar is shown in Fig. 3. Those which CDG reared in 2010 were variable in the extent of the dorsal black markings on segment A2. In the 2011 individual, these are restricted to a pair of near circular dorsolateral spots, but in the 2010 rearing in some cases, these spots were joined dorsally to form a black bar across the dorsal part of segment A2. The 2011 individual continued development for a further seven days until 22 October when it stopped feeding and prepared to pupate. However, for the next five days the caterpillar spent most of its time resting under the lid of the rearing container and excreted watery frass, and it was only on 27 October that it suspended itself from the container lid by the anal segment. CDG did not note this delay or watery frass in the material which he reared in 2010, so it is atypical.

Fig. 2. Leaf roll of *Memphis pithyusa morena* viewed from the basal end showing caterpillar head blocking entrance (collection details as Fig. 1).

Two days after suspending itself, the caterpillar pupated (Fig. 4), and 15 days later a male emerged (Fig. 5).

Barcant (1970) does not illustrate this species in colour, so we show here a pair of pinned adults (Fig. 6). The chestnut brown colouring on the upperside of female ssp. *morena* is characteristic, being light blue in ssp. *pithyusa.*

The caterpillar and pupa shown here (Figs. 3-4) are similar to those shown in black and white for *M. pithyusa pithyusa* from El Salvador by Muyshondt (1975). However, Muyshondt's photographs of the final instar caterpillar show that segment A2 has a broad black band running from the lateral white spot over the dorsum, as CDG noted for some Trinidad caterpillars in 2010. Muyshondt's final instar caterpillar also has dark shading laterally on segments T2-A1, A4-A8, which is not found in our cater-

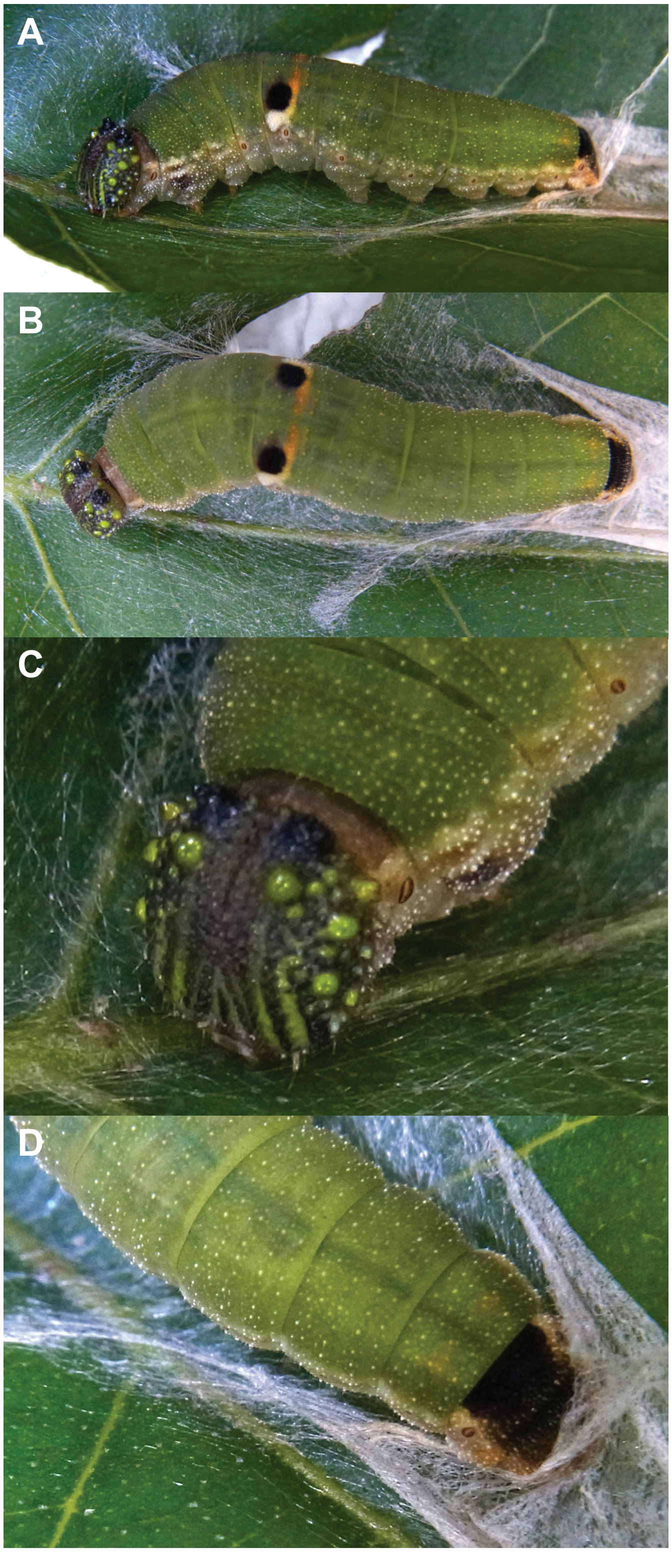

Fig. 3. Final instar caterpillar of *Memphis pithyusa morena*, 28 mm (collection details as Fig. 1); note the silk lining of the shelter on which the caterpillar rests. **A.** dorsolateral view; **B.** dorsal view; **C.** anterodorsolateral view of head and anterior segments; **D.** posterodorsolateral view showing anal segment.

Fig. 4. Pupa of *Memphis pithyusa morena*, 11 mm, 30 Oct., 2011 (collection details as Fig. 1).

Fig. 5. Newly emerged adult male of *Memphis pithyusa morena*, 13 Nov., 2011 (collection details as Fig. 1).

pillar. The photographs of *M. pithyusa pithyusa* in Janzen and Hallwachs (2011) show that the caterpillars in Costa Rica are similar to those from El Salvador, but variable with regard to the extent of these lateral markings, the colour of the tubercles on the head (some can be orange or red), the colour of the legs (varying to red in some individuals) and the extent of the black posterior marking.

In conclusion, there do not seem to be any significant differences between our observations of the early stages of *M. pithyusa morena* and those of *M. pithyusa pithyusa* from Central America, although observations of more individuals from Trinidad are needed to define the extent of variation in the caterpillars. Accordingly, the treatment of *morena* as a subspecies of *pithyusa* (Lamas 2004) is supported rather than treating *morena* as a separate valid species as Comstock (1961) did.

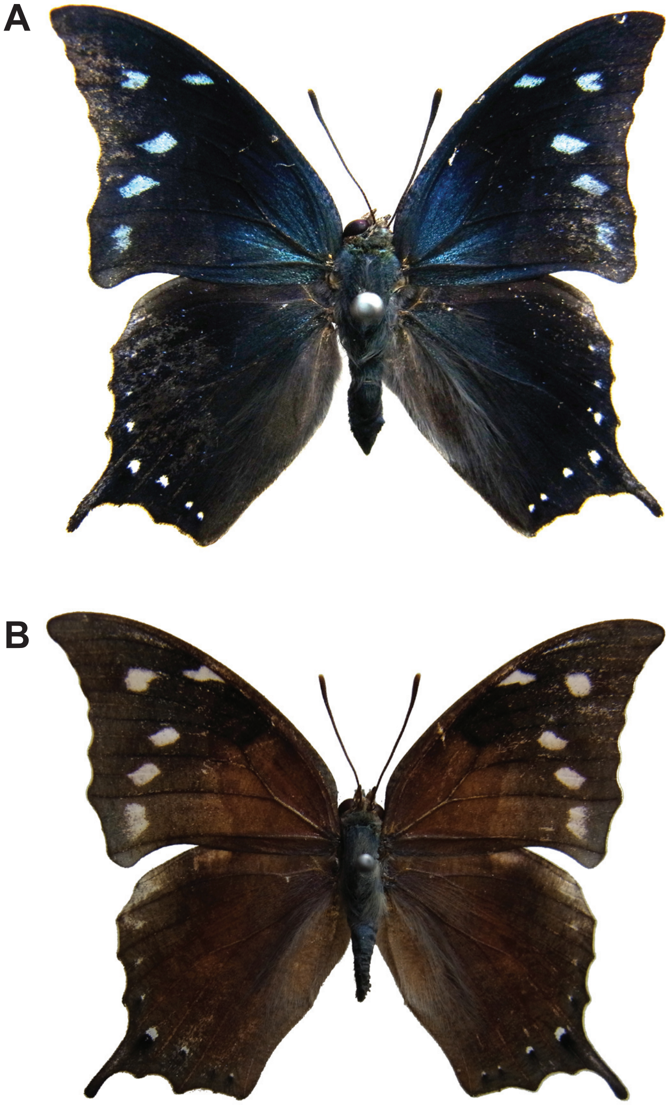

Fig. 6. Pinned adults of *Memphis pithyusa morena*. **A.** male, collection details as Fig. 1, 39 mm wingtip to wingtip; **B.** female, collected as caterpillar on *Croton niveus*, Point Gourde, 29 Aug., 2010, adult 2 Oct., 2010, C. De Gannes, 47 mm wingtip to wingtip (see De Gannes 2011).

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A New Subfamily of Wasps Recorded for Trinidad, West Indies (Hymenoptera: Crabronidae: Astatinae)

The 120 known species of Crabronidae represent a substantial component of the aculeate Hymenoptera of Trinidad, West Indies (Starr and Hook 2003). This world-wide family of solitary wasps is divided into eight subfamilies (Pulawski 2006), of which four are recorded from Trinidad. My purpose here is to report the first record of a fifth subfamily, Astatinae, for the Trinidad fauna.

On 19 July, 2011 at about noon, I noticed a black wasp perched on the ground near what appeared to be a fresh tumulus, the soil around the entrance of a burrow. This wasp perched near the tumulus for several moments before I collected her. The location was near the beginning of a trail/dirt road into secondary forest in the Caura Valley (10.684N, 61.378W) of the Northern Range.

The specimen is an all-black female *Astata* sp. *Astata*, with 80 species worldwide (Pulawski 2006), is the largest of the four known genera of Astatinae. Of the 10 species known from South America, only *A. lugens* Taschenberg and *A. gigas* Taschenberg are entirely black (Parker 1968b; Amarante 2002). The Trinidad wasp matches both of these in some characters, but differs significantly in some others. For example, the forewings in *A. gigas* are uniformly dark brown-violaceous, while in *A. lugens* the forewing is clear except for a light brown band in the area of the marginal cell. While the forewings of the Trinidad *Astata* are mostly dark brown-violaceous, they are lighter toward the distal margin (outside of the cellular area), and the basal cell is mostly clear with some coloring at the distal margin. *A. gigas* has the abdominal sterna clothed with long, thick, posteriorly-directed setae, while in *A. lugens* sternum II is densely clothed with off-white setae; the Trinidad species has only sternum II clothed with relatively sparse long, white setae. *A. gigas* has a striate propodeal enclosure, while in *A. lugens* the propodeal enclosure is reticulostriate with reticules open and irregular, which agrees with the Trinidad *Astata*. All three species have the median clypeal lobe truncate and upturned at the apex.

Parker (1964) also revised *Astata* from Mexico and Central America. In this region, as well, only two all-black species are known (*A. stangei* Parker and *A. bakeri* Parker), neither of which matches the Trinidad *Astata*. Parker (1968a) recognized two Caribbean species, but both have colored abdomens and differ significantly in other characters.

Accordingly, the Trinidad *Astata* does not match any known Neotropical species and appears to be an undescribed species. *Astata* are known to dig multicellular ground nests that are provisioned with adult and immature Hemiptera: Heteroptera, particularly Pentatomidae (Evans 1957).

It is rather surprising that this wasp should have gone unnoticed up until now, as Trinidad has had substantial collecting efforts directed towards crabronid wasps, most notably by Desmond Vesey-FitzGerald and Edward McC. Callan in the first half of the 20th century. I, myself, have collected wasps in Trinidad almost yearly since 1995, without finding the present species before.

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Laelapid Mites (Acari: Laelapidae) Collected from Small Mammals in Trinidad, Trinidad and Tobago

Mites (Acarina) are minute arthropods barely visible to the naked eye, but some belonging to the family Laelapidae are as large as some ticks and are ectoparasites of cricetid rodents. Laelapidae mites are not well studied and less than a 100 species are described. As part of a study on arboviruses (insect, tick and mite-transmitted viruses) by the Trinidad Regional Virus Laboratory (TRVL), small mammals were trapped from various localities in Trinidad and blood samples processed for virus isolations and antibody determinations in an attempt to determine their role in the maintenance of arbovirus cycles. Ectoparasites were combed from these mammals and processed for virus isolations, but some were kept for specific identifications. Over a period of 10 years in Trinidad, Aitken *et al.* (1969) tested 5312 *Gigantolaelaps* sp. and 16,207 smaller laelapid mites for virus isolations, but only one strain of a virus (Cocal) was recovered. Apart from the Aitken (1969) study, there has been no written report about laelapid mites occurring in Trinidad.

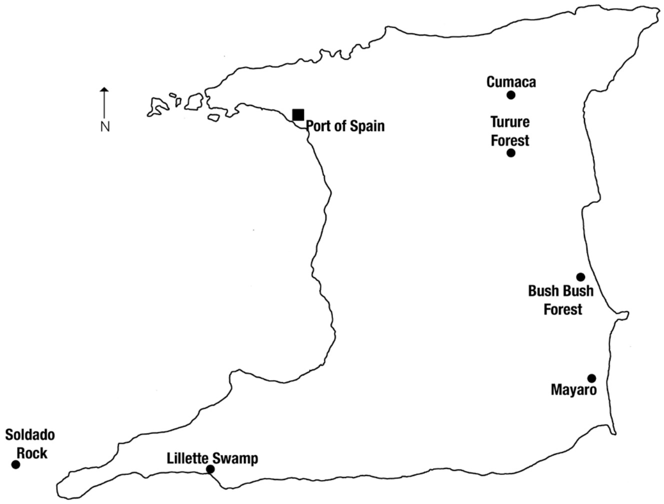

Fig. 1. Collecting sites for small mammals and laelapid mites in Trinidad.

The present study was conducted on arbovirus studies at Bush Bush Forest, Cumaca, Cedros (Lillette Swamp), Mayaro, Soldado Rock and Turure Forest (Fig. 1). The small mammals representing eight species were trapped from these areas and the mites collected are given in Table 1. Specimens of each species and accompanying data were deposited in the TRVL (now Caribbean Epidemiology Centre). Museum collections were identified by David A. Parsons of Ohio State University to whom I offer my sincere thanks.

A total of 783 small mammals was examined. Nine species of laelapid mites were found on 539 rodents representing eight mammal species. No laelapid mite was found on the following mammal species: 26 *Didelphis marsupialis,* 41 *Marmosops fuscatus* (formerly *Marmosa fuscata*), 100 *Marmosa robinsoni* (formerly *M. mitis*), 27 *Caluromys philander,* 7 *Oecomys trinitatis* (formerly *Oryzomys concolor),* 19 *Rattus rattus,* 8 *Mus musculus* and 2 *Makalata didelphoides* (formerly *Echimys armatus*).

The following laelapid mites were found (Table 1):

***Androlaelaps fahrenholzi* (Berlese)** was found on only two of the eight species of rodents, *Hylaeamys megacephalus* (formerly *Oryzomy capito)* and *Proechimys trinitatis* (formerly *P. guyannensis trinitatis)* examined. Furman (1972) noted that species of *Zygodontomys* in Venezuela were commonly infested with this mite.

***Androlaelaps rotundus* (Fonseca)** was found only on one species of rodent, *Necromys urichi* (formerly *Akodon urichi), Akodon urichi* was a common host for the mite in Venezuela (Furman 1972).

Gigantolaelaps wolffsohni group. Nine collections were made from Cumaca (6) and Turure Forest (3). Furman (1972) described members of this group collected from *Oryzomys fulvescens* in northeastern Venezuela.

***Gigantolaelaps oudemansi* Fonseca** mites were collected from *Hylaeamys megacephalus* captured at Lillette Swamp, Cedros and Turure Forest. *G. oudemansi* was collected from *Oryzomys capito* and other *Oryzomys* species from Venezuela (Furman 1972).

***Laelaps dearmasi* Furman** and **Tipton.** Of eight *Zygodontomys brevicauda* (formerly *Z. brevicauda soldadoensis)* collected from Soldado Rock, six were infested with this species of laelapid mite. *L. dearmasi* was found only on *Z. brevicauda.* In Venezuela, Furman (1972) noted that this was the most common laelapid mite found and noted that the most commonly infested host was *Zygodontomys brevicauda*.

Laelaps* nr. *castroi. A single collection was made from *Nectomys palmipes. L. castroi* was collected mainly from *Oryzomys fulvescens* in Venezuela (Furman 1972).

***Laelaps paulistanensis* Fonseca** was collected only at Cumaca and only from *Proechimys trinitatis,* but Furman

Table 1. Laelapid mites collected from rodents from various localities in Trinidad.

Mite	Host	Locality	No. Examined	No. Positive
Androlaelaps fahrenholzi	*Hylaeamys megacephalus*	Bush Bush Forest	2	1
		Cedros	5	0
		Cumaca	2	0
		Mayaro	5	0
		Turure Forest	132	2
	Proechimys trinitatis	Cumaca	105	1
		Mayaro	1	0
		Turure Forest	185	0
Androlaelaps rotundus	*Necromys urichi*	Cumaca	1	0
		Mayaro	2	0
		Turure Forest	31	5
	Hylaeamys megacephalus	Bush Bush Forest	1	0
Gigantolaelaps wolffsohni group	*Nectomys palmipes*	Cumaca	25	5
		Mayaro	1	0
		Turure Forest	11	3
	Rhipidomys couesi	Cumaca	9	1
		Turure Forest	1	0
Gigantolaelaps oudemansi	*Hylaeamys megacephalus*	Cedros	5	4
		Cumaca	2	0
		Turure Forest	132	6
Laelaps dearmasi	*Nectomys palmipes*	Cumaca	25	1
	Zygodontomys brevicauda	Soldado Rock	8	6
	Zygodontomys brevicauda	Turure Forest	11	0
Laelaps* nr. *castroi	*Nectomys palmipes*	Cumaca	25	0
		Mayaro	1	0
		Turure Forest	11	1
Laelaps paulistanensis	*Proechimys trinitatis*	Cumaca	105	2
		Mayaro	1	0
		Turure Forest	185	0

Mite	Host	Locality	No. Examined	No. Positive
Mysolaelaps heteronynchus	*Nectomys palmipes*	Cumaca	25	1
		Mayaro	1	0
		Turure Forest	11	0
	Proechimys trinitatis	Cumaca	105	1
		Mayaro	1	0
		Turure Forest	185	0
	Rhipidomys couesi	Cumaca	9	3
		Turure Forest	1	0
Steptolaelaps heteromys	*Heteromys anomalus*	Bush Bush Forest	3	1
		Cedros	4	1
		Cumaca	1	0
		Mayaro	4	0
		Turure Forest	5	0

(1972) found species of *Rhipidomys* was the most commonly infested host.

Mysolaelaps heteronynchus **Fonseca** was collected only from Cumaca. Three of the five collections came from *Rhipidomys couesi.* In Venezuela, this laelapid was commonly found on species of *Rhipidomys*.

Steptolaelaps heteromys **Fox** was found only on *Heteromys anomalus* and likewise Furman (1972) found this rodent to be commonly infested in Venezuela.

Laelapid mites were found commonly on cricetid rodents and all represent new locality and host records for Trinidad. In addition to the above mites identified, two collections of an unidentified *Laelaps* were made from *Nectomys palmipes* captured at Cumaca. Laelapid mites are little studied (Furman 1972) in the Neotropics and less so in Trinidad. In view of more recent studies and changing taxonomy of the mites in South America, the Trinidad specimens should be restudied.

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The Status of Four Aquatic Crustaceans from Grand Cayman, West Indies

The status of four species of aquatic crustaceans from Grand Cayman is being reported. These include: *Anopsilana crenata* (Cirolanidae), *Macrobrachium heterochirus* (Palaemonidae), *Procambarus alleni* (Cambaridae), and *Stygiomysis* sp. (Stygiomysidae).

Anopsilana crenata is an endemic, troglobitic isopod found in caves of Grand Cayman. This unpigmented, blind species was first reported and described by Bowman and Franz (1982) from West Bay Cave (known locally as "Blue Hole"). A detailed description of this anchialine cave was also provided in the 1982 manuscript. R. Franz collected additional specimens from McLaughlin Well Cave and reported observing this species in Dolphin Cave during 1986 (Smithsonian Institution 2007). West Bay Cave was visited on 30 May, 2011 and sampling revealed the population of *A. crenata* remains abundant with both juveniles and adults being present.

A single dead specimen of the prawn *Macrobrachium* was collected from a seasonal wetland pond near Red Bay by T. Galvin on 12 April, 2007. Although the specimen was damaged, it could still be identified as *M. heterochirus*. This species of palaemonid shrimp has been reported from throughout the Caribbean Basin (Chace and Hobbs 1969; Bass 2003), but this specimen represents the first report of any taxon of Palaemonidae from the Cayman Islands. Further collections in nearby similar habitats have failed to yield additional specimens, so the population status of *M. heterochirus* on Grand Cayman is unknown.

Numerous specimens of *Procambarus alleni,* commonly known as the blue crayfish, have been collected in the vicinity of the Queen Elizabeth II Botanic Park. Several individuals were first observed in a low-lying area of the botanic park by J. Marotta during late 2008. This species was absent from invertebrate samples collected in that area prior to mid 2008 (Bass 2009), so it is presumed the blue crayfish was introduced during the later half of 2008. Since that time, this species has spread to similar habitats and ponds throughout the park and nearby properties. The native range of *P. alleni* is limited to south-central Florida (Hobbs 1976). Hobbs *et al*. (1989) suggested invasive species of crayfish disrupt the balance of aquatic ecosystems when they are introduced into places where they previously have been absent. Studies to detect possible deviations in community structure continue, but no measurable changes that may be linked to *P. alleni* have been observed.

A single specimen of the mysid *Stygiomysis* was collected from West Bay Cave on 30 May, 2011. K. Meland (pers. comm.) has examined the *Stygiomysis* and narrowed it down to be either *S. clarkei* or *S. holthuisi*. In terms of morphology, these two species are very similar, with differences being mostly in characters related to size. *S. holthuisi* reaches lengths up to 10 mm, while *S. clarkei* only grows to 6 mm. The Cayman specimen is 9 mm, which leans towards *S. holthuisi*. Furthermore, *S. holthuisi* has a wide distribution in the Caribbean region, while *S. clarkei* is only known from the Turks and Caicos Islands (Iliffe 2011). Based on these observations, this specimen is probably *S. holthuisi*. However, additional study is required to be certain of its identification and determine the population status of this species on Grand Cayman.

Biodiversity investigations continue on Grand Cayman to monitor the status of all four species of these aquatic crustaceans.

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I wish to thank The Cayman Department of Environment and Cayman Turtle Farm for providing access to the sites and permission to collect specimens of aquatic invertebrates. In addition, Kenneth Meland and Tom Iliffe provided taxonomic assistance identifying the stygiomysid and H. Hobbs, III confirmed identification of the crayfish.

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First Record of the Opossum *Didelphis marsupialis* from the Island of Gaspar Grande off North-Western Trinidad, Trinidad and Tobago

The black-eared opossum *Didelphis marsupialis* Linnaeus (Mammalia: Didelphimorphia: Didelphidae) ranges from Mexico to north-eastern Argentina (Redford and Eisenberg 1992) and parts of the Lesser Antilles. In Trinidad and Tobago where it is called the manicou, it is still fairly common throughout both islands and can be found in a variety of habitats including primary and secondary forests, agricultural areas and urban yards.

At mid-morning on 14 June, 2011 during a search for reptiles in a limestone sinkhole at Pointe Baleine on the island of Gaspar Grande, we observed an adult male *Didelphis marsupialis* in a lateral cavity about 20 cm wide and about one metre deep in the rock wall near the lip of the sinkhole. We watched and video recorded the animal for less than a minute before it moved up into a vertical shaft and out of view.

Gaspar Grande is a small satellite island about 133 hectares in area and 975 m off the north-western peninsula of Trinidad. The island is covered by tropical deciduous seasonal forest and fringed by many holiday homes and guest houses. Our 2011 observation of *Didelphis marsupialis*, coupled with a previous report of 'manicous on the island' by a long time owner of a Gaspar Grande holiday home (SPC 2007, pers. obs.), suggest that a population of these opossums is resident on the island. However, we were unable to discover any published records of wild native non-volant mammals on Gaspar Grande.

Boos (1990) recorded *Didelphis marsupialis* from the nearby satellite island of Monos. Our record is the first for the species on Gaspar Grande. Although recent human mediated introduction and/or recent natural colonization cannot be entirely ruled out, we are of the opinion that our observation lends further support to the notion that the fauna present on the satellite islands north-west of Trinidad is largely relict of the Pleistocene and the product of vicariance (Boos 1984); representing populations that became isolated after sea levels rose at the end of the last ice age and drowned low lying areas, leaving the higher areas as the satellite islands as they now exist with their faunal populations separated from those on Trinidad and mainland South America.

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Feeding Behaviour of a Captive Giant Centipede *Scolopendra gigantea* in Trinidad, West Indies

The South American Giant Centipede *Scolopendra gigantea* Linnaeus (Arthropoda: Myriapoda: Chilopoda: Scolopendridae) is the largest species of centipede in the world (Shelley and Kiser 2000). It is found in northern Colombia, northern Venezuela, Aruba, Curaçao, Margarita Island and Trinidad (Shelley and Kiser 2000). In Trinidad, based on specimens in the University of the West Indies Zoology Museum and on personal experience, the giant centipede is mainly found in the north-west of the mainland and on the small islands off the north-west coast.

On 12 April, 2011, I observed the feeding behaviour of a captive centipede. It had been collected the previous day from leaf litter in the tropical dry forest on Chacachacare Island, Trinidad during filming of a documentary by WAG TV for the Discovery Channel. It was identified using the diagnostic features shown in Shelley and Kiser's 2000 paper.

The centipede was placed in a glass tank 90 cm long by 30 cm wide by 30 cm high with a substrate of soil from the forest where it was collected. Large items such as leaves and twigs were removed to allow unimpeded observation.

Ten captive-bred Six-spot cockroaches, *Eublaberis distanti* (Kirby), were placed into the middle of the tank at 1505 h. The centipede was making laps around the perimeter of the tank moving its antennae up and down, but it did not seem to respond to the visual stimulus of the cockroaches. However, as soon as one of its antennae touched a cockroach, it went on the attack. The centipede ran over the top of a cockroach and pushed it to the edge of the tank. It then grasped this first cockroach using legs 8-16 (numbered from the anterior end) and held the cockroach so that its ventral side was exposed. The centipede then proceeded to inject venom by biting the cockroach several times using its toxicognaths. Elzinga (1996) reported a similar method of grasping in an account of a *Scolopendra viridis* Say centipede feeding on American cockroaches *Periplaneta americana* (Linnaeus).

Whilst the centipede was injecting venom into the first cockroach, a second cockroach crawled over the hind legs of the centipede. This caused the centipede to attempt to grab the second cockroach using legs 20-21. The centipede did not manage to get a firm grasp so it released the first cockroach and turned around quickly to grab the second cockroach using legs 2-9. The centipede held the second cockroach from above and started to inject venom by biting repeatedly into the neck of the cockroach. After five minutes the centipede had bitten off the head of the second cockroach and then spent the next 45 minutes eating most of the cockroach apart from the legs, wings and head-shield.

While the centipede was dealing with the second cockroach, the first cockroach had remained on its back with its antennae twitching, but otherwise not moving. Studies on scolopendrid venom have shown that it has a very fast acting paralytic effect on insects (Rates *et al.* 2007).

Whilst the centipede had been catching, killing and eating the second cockroach, it had no physical contact with the first cockroach. However, at 1615 h, as soon as the centipede had finished eating the second cockroach, it turned back instantly to where it had left the first cockroach and grasped it again and started to feed (Fig. 1). Thirty-five minutes later it had finished eating most of the first cockroach and then proceeded to clean itself.

Although there was a gap of 50 minutes between leaving the first cockroach after immobilising it and then finding it again, the centipede showed no hesitation in doing so. The speed with which the centipede relocated the first cockroach suggests that it remembered its location as opposed to just randomly coming across it. This combined with the fact that the centipede dealt with two prey items in quick succession and manipulated them in different ways and using a different combination of legs, suggests that scolopendrids have more complicated feeding behaviour than may at first be apparent.

Fig. 1. Centipede feeding on first cockroach.

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Thank you to the film crew from WAG TV for the transport to Chacachacare Island and for a copy of the footage taken.

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Nesting Behaviour by a Male Plumaged Black-throated Mango Hummingbird, *Anthracothorax nigricollis nigricollis*

On the 19 January, 2012 at Sudama Steps in South Oropouche, the author and Feroze Omardeen observed a male plumaged Black-throated Mango Hummingbird exhibiting nesting behaviour. It was observed checking the nest and tucking in any stray bits. It flew off briefly but returned to spend much of its time sitting on the nest as though incubating.

In general, male hummingbirds are polygamous and may mate with several females during the breeding season. All nest building, incubation, and rearing of the young are carried out solely by the female (Schuchmann 1999). Schuchmann goes on to cite a few reports of males participating in incubation or rearing the young, particularly in some tropical species, but generally concludes that there is insufficient evidence to confirm any parental care by males.

There are several examples of what appear to be male hummingbirds involved in nesting behaviour, but it is usually considered an anomaly. With respect to the Black-throated Mango, a male has been photographed sitting on a nest (apparently with eggs) by Luciano Breves in Brazil (Breves 2010). Unfortunately, the nest was destroyed before the observer could determine whether the chicks would be reared successfully.

This record provides yet another example of a hummingbird in male plumage involved in nesting behaviour.

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Fig. 1. Male plumaged Black-throated Mango sitting on a nest. Photo: M. Rochford.

First Records for Four Reptile Species from Gasparillo Island off North-Western Trinidad, Trinidad and Tobago

Gasparillo Island (also known as Centipede Island) is a tiny satellite located 220 m off the north-western peninsula of Trinidad at 10°40´34.36´´N, 61°39´11.83´´ W, near to Chaguaramas Bay. The island covers approximately 2.11 hectares, has an approximate elevation of 25 m and is composed primarily of rugged limestone rock with fairly shallow soil that hosts a tropical deciduous seasonal forest. Gasparillo Island has an even smaller satellite of its own called Little Centipede Island. It is but a rock a few metres high, 0.037 hectares in extent with only a few scrubby trees, and is only 17 m from Gasparillo Island. In his primary paper on the terrestrial reptiles of the islands off north-western Trinidad, Boos (1984) treated these two islands as a unit and noted the rugged nature of the terrain and difficulty of safely landing on Gasparillo Island, suggesting these as reasons for the lack of past herpetological collecting effort there. A single lizard, *Anolis aeneus,* was noted for these two small islands, but it was not specified if the species was known from both islands, or from only one (Boos 1984).

We made three visits to Gasparillo Island in search of reptiles. The first was on a sunny day with passing showers between 1600 h and 1800 h on 13 January, 2010 (PC and JL); the second was on a sunny day between 1100 h and 1500 h on 24 March, 2011 (SPC and MGR); and the final visit was made on an overcast day between 1200 h and 1400 h on 11 April, 2011 (SPC and MGR). The most intensive search was made on the second visit, during which we moved over a wide section of the island, spanning both the entire length and breadth, and from sea level to the summit. We searched under fallen logs and rocks, in crevices between rocks and bark, in leaf litter and soil, along lower sections of the trunks and branches of trees and shrubs as well as inside a small cave. During our three visits, we did not observe *Anolis aeneus*, but noted four other species of reptiles, all of which are new records for Gasparillo Island and are reported as follows:

***Amphisbaena fuliginosa* L.**
(Reptilia: Squamata: Amphisbaenia: Amphisbaenidae).

We found one adult worm lizard on 13 January, 2010 in the soil under rotting wood on the north-east facing side of the island. The animal was approximately 30 cm long and appeared in good physical condition.

***Iguana iguana* L.**
(Reptilia: Squamata: Sauria: Iguanidae).

Boos (1984) speculated that iguanas were probably present on Gasparillo and Little Centipede. We observed a sub-adult iguana about 1.5 m above ground in the branches of a shrub on the crest of the island on 11 April, 2011. On the same day, scat a few centimetres long and composed of tightly packed desiccated leaves was found on the forest floor. It was presumed to be from this species.

***Gonatodes vittatus* Lichtenstein**
(Reptilia: Squamata: Sauria: Sphaerodactylidae).

We noted two adult males and two adult females on 24 March, 2011 and two adult females on 11 April, 2011. These streak lizards were on rocks and lower segments of tree trunks.

***Gymnophthalmus underwoodi* Grant**
(Reptilia: Squamata: Sauria: Gymnophthalmidae).

We saw two adult shiny lizards foraging in leaf litter on 24 March, 2011.

Investigation of the biodiversity of the satellite islands of Trinidad and Tobago remains a fascinating pursuit. All of the species noted during our surveys of Gasparillo Island have also been recorded from the nearby larger satellite island of Gaspar Grande (Boos 1984; Boos and Quesnel 1994), as well as from the main island of Trinidad. The herpetofauna of Gasparillo Island and other nearby larger satellite islands may provide opportunities to study various aspects of community ecology including predator-prey interactions and competition.

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New Locality Records for the Holothurians *Parathyone suspecta* and *Holothuria cubana* in Trinidad, West Indies

The holothurian taxa of the Caribbean is well known at a regional level with 63 species recorded (Alvarado 2010). Of these, 18 species have been recorded from Trinidad and Tobago (Deichmann 1963; Tikasingh 1963, 1973; Hendler *et al.* 1995) and of the 18, only seven have been recorded from Trinidad: *Chiridota rotifera* (Pourtales), *Holothuria glaberrima* (Selenka), *Holothuria grisea* Selenka, *Holothuria surinamensis* Ludwig, *Isostichopus badionotus* (Selenka), *Pentacta pygmaea* (Theel) and *Pseudothyone belli* (Ludwig).

The holothurian specimens held in the University of the West Indies Zoology Museum (UWIZM) were investigated in October, 2011 as part of a student project. The majority of these specimens, collected over the past 30 years, were unidentified and many had very little locality or collector information. The specimens were identified by the authors by examination of the gross anatomy and microscopic examination of spicules. Of the species identified, two of them had not been recorded before from Trinidad - *Parathyone suspecta* (Ludwig) (Fig.1) and *Holothuria cubana* Ludwig (Fig. 2).

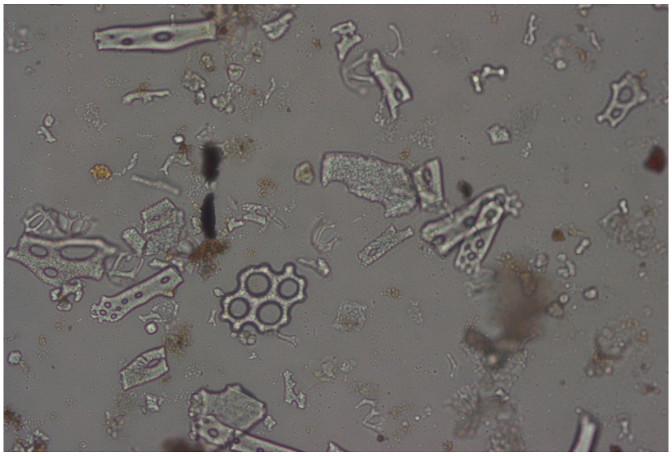

Fig. 1. Spicules of *Parathyone suspecta.*

Three *P. suspecta* were collected from the waters off Cocorite in north-west Trinidad by Pooran Badal on 14th April, 1986 (UWIZM.2011.21.14). The preferred habitat for *P. suspecta* is amongst rocks in the intertidal zone and sea grass beds (Hendler *et al*. 1995) and off Cocorite this is exactly the kind of habitat found. Previous known distribution of *P. suspecta* includes the Lesser Antilles and Colombia (Hendler *et al.* 1995).

Two *H. cubana* were collected from William's Bay, north-west Trinidad by one of us (M.N.S.C.) on 15th September, 2011 (UWIZM.2011.21.11) and one more was collected from the same site by one of us (M.G.R.) on 14th October, 2011 (UWIZM.2011.21.17). All specimens were found during the day sheltering under rocks at about one metre deep in an area with a mix of sand, rocks and sea grass.

H. cubana is often hard to find due to its habit of clinging to the underside of rocks or rubble and burrowing into sand. It is also often covered in a layer of sand and other detritus which helps camouflage it (Fig. 3). The known distribution of *H. cubana* includes Barbados and Venezuela (Hendler *et al.* 1995) so it is not surprising to find this species in Trinidad positioned as it is in between these two countries.

The lower numbers of holothurian species recorded for Trinidad compared with Venezuela and Tobago may be due to the lack of suitable habitat off the coast of Trinidad, in particular the effect of the large volume of fresh water coming from the Orinoco River in Venezuela into the Gulf of Paria could limit numbers. However, a more important factor may be that so little work has been done on holothurians in this country. It is possible that further

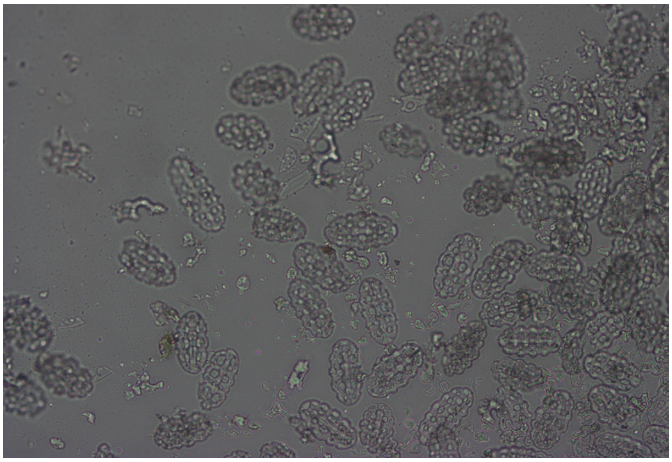

Fig. 2. Spicules of *Holothuria cubana.*

Fig. 3. *Holothuria cubana* in sand and sea grass.

investigation of certain habitats could reveal more species.

In many parts of the Caribbean, including Mexico, Nicaragua and Panama, several species of sea cucumber are harvested for commercial use. In most cases, very little is known about the sustainability of the fisheries (Toral-Granda 2008). As there is the possibility of commercial exploitation in Trinidad in the not too distant future to feed foreign markets mainly in south-east Asia, it is very important that comprehensive surveys are conducted sooner rather than later so that the fishery can be managed in a sustainable way.

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Observation of Apparent "Parental Care" of Eggs by a Juvenile *Azilia vachoni* (Araneae: Tetragnathidae)

Spiders exhibit varying degrees of parental care of immatures, varying from none (most species) to third instar spiderlings occupying their maternal web which is seen in the semi-social tarantula *Ischnothele caudata* of the family Dipluridae (Simon) (Jantschke and Nentwig 2001), to the most social spider species *Anelosimus eximus* (Keyserling). Here I report observations on retreats of the northern South American tetragnathid *Azilia vachoni* (Caporiacco) containing eggs and an individual in its second or third instar.

The favoured microhabitat occupied by adult and semi-adult *A. vachoni* is the semi-open space found between buttress roots (Sewlal 2009). Other favoured microhabitats observed for this species include between the forest floor and fallen logs or tree hollows (Sewlal, pers. obs.).

These observations were carried out in the Arena Forest Reserve, Trinidad, West Indies (10°34'N, 61°14'W).

Observations were made on 13 individuals, whose orb webs were orientated either vertically (85%) or horizontally (15%) between the leaves of *Philodendron* sp. vines ascending two tree trunks. However, the hubs were suspended from retreats giving the webs a conical appearance. The retreats were also conical in shape and were made of loose granular debris.

Webs of this form were observed on two trees. The trunk of the first tree was occupied by 38 retreats starting at approximately 0.3 m above ground level and covering a vertical distance of one metre up the trunk, while the second tree had 13 retreats starting at 0.6 m from ground level and covering over about two metres. Further webs and retreats were noticed higher up. However, not all webs and retreats were recorded as they were too high for all of the details to be accurately described by the collector.

Out of a total of 13 webs sampled, in all except two webs, spiders occupied the retreat. Four retreats were collected and placed in vials containing 70% alcohol. Dissection of these retreats revealed them to contain between six to 11 eggs. The retreats also contained a female which was either a second or third instar. The female appeared not to be the mother of the eggs and it is not obvious if it is an older sister of those eggs or an individual that wandered into the retreat.

Many spider species perform a pattern of maternal behaviour referred to as "egg sac guarding" which consists of the females staying close to the egg sac during its incubation period (Horel and Gundermann 1992), which are recorded from a range of families (Fink 1987). The presence of the individuals of *A. vachoni* in these retreats and its inclusion in the web design suggest that these individuals were carrying out this behaviour. It is also possible that other retreats contained other individuals but abandoned them when disturbed during the recording process. This species is very sensitive to disturbance and had been noticed to drop from its web due to slight disturbances like blowing on its web (Sewlal, pers. obs.).

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Two Additional Spider Families, Nemesiidae and Tengellidae, Recorded from Trinidad and Tobago

Currently, 50 families of spiders are documented and confirmed to be found in Trinidad and Tobago (Sewlal and Cutler 2003; Sewlal 2010) belonging to the infraorders Araneomorphae and Mygalomorphae. A search of the database of the Field Museum, Chicago, USA has yielded the presence of two more families, Nemesiidae (Mygalomorphae) and Tengellidae (Araneomorphae), bringing the total number of families recorded from Trinidad and Tobago to 52. The records for both families each consist of a single adult male of unknown genus and species collected in montane forest by S.B. Peck and J. Kukalova-Peck. The specimen of the family Nemesiidae was collected using a flight interception trap (FIT) at 16 km north Arima in Andrew's Trace (620 m elevation), between 24 June to 7 July, 1993 (Catalog no. FMNH-INS-61277; Accession no. FMHD#93-440). A detailed description of this family is available at Raven (1985). The specimen belonging to the family Tengellidae was collected in Maracas Valley above Loango Village (600 m elevation), from malaise traps between 22 June to 6 July, 1993 (Catalog no. FMNH-INS-61129; Accession no. FMHD#93-443). Ubick and Richman (2009) give the characteristics of this family.

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New Records of Two Freshwater Gastropod Molluscs for Trinidad, West Indies

The freshwater molluscs of Trinidad have been studied since the 1860s. R.J.L. Guppy wrote many papers on the terrestrial and freshwater molluscs of Trinidad, culminating in his comprehensive list in 1893. In this he names nine species of freshwater gastropods. E.A. Smith, working at the same time, came up with ten species in his 1896 paper, although he did write that one of them was possibly a synonym of one of Guppy's species. Workers since then have added a few more and by 2007 Maharaj and Alkins-Koo had listed 15 potential species from nine families: Ampullariidae, Ancylidae, Planorbidae, Thiaridae, Neritidae, Physidae, Lymnaeidae, Hydrobiidae and Pleuroceridae. However, several of the specimens found in this last study were not identified to species level.

This note reports on one new record of an Ampullariidae and one new record of a Lymnaeidae. Although information found during this study indicates that both of these species have been in Trinidad for several years, there have as of yet been no records in the literature. Specimens were identified using F.G. Thompson's 1984 manual and the Lymnaeidae was confirmed by Kenneth Hayes at the University of Hawaii.

Between May 1992 and January 2012, one of us (RSM) found specimens of the Spike-topped Apple Snail *Pomacea diffusa* (Blume) at several sites (Fig. 1). The sites span three central Trinidad drainages including the Caroni, Guayamare and Cunupia systems. Specimens can be found along the Trantrill Road, St. Augustine and in some isolated artificial drainages in Arima. There is a high density of approximately 40 individuals per m^2 in some shallow drains within the Cunupia network where they seemingly outnumber the native *P. glauca* (Linnaeus) (Fig. 2). There was one isolated pond at the base of the San Fernando Hill in the early 1990s with a large population (RSM); this population is now extinct but it is included here for the record. A lone specimen was also collected in 2009 from the artificial irrigation trenches which tap the Oropouche Lagoon in south Trinidad.

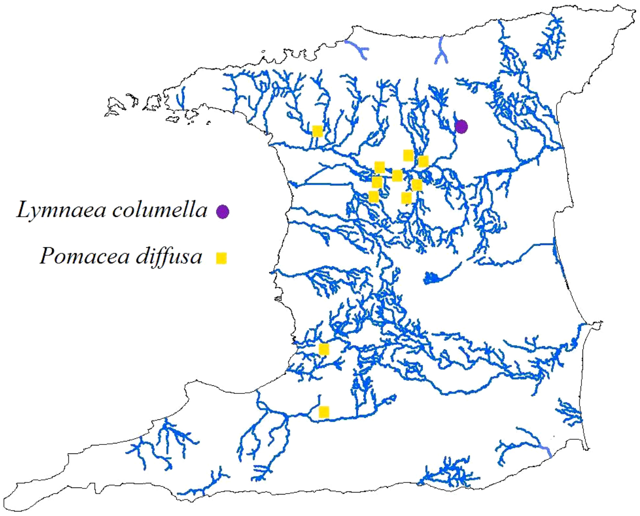

Fig. 1. Central Trinidad distribution of *Pomacea diffusa* within the low portions of the Caroni Drainage and middle courses of the Guayamare and Cunupia Rivers. The single site where *Lymnaea columella* was collected is indicated at the upper site on the Aripo River.

Fig. 2. High density of golden yellow *Pomacea diffusa* outnumbering the brown *P. glauca.*

Although *Pomacea diffusa* is South American in origin, it is very unlikely it is a natural colonizer based on its distribution pattern spanning from central Trinidad. There are two ornamental fish importers located at the core of this distribution with the network of the Caroni, Guayamare and Cunupia Drainages surrounding them, and it is quite likely that this was the source of the snails. This particular species could be considered an alien invasive as, based on the high densities of individuals observed, it clearly outnumbers the native Ampullariidae at certain sites.

Lymnaea (Pseudosuccinea) columella Say (Fig. 3) was collected by RSM in June 2011 at the upper reaches of the Aripo River in the shallow man-made channels used for crop irrigation (Fig.1). It is quite possible that specimens of this species were collected by L.D. Maharaj during the mid 2000s, but as they were only identified to family level and the original specimens cannot be located, this cannot be confirmed.

Lymnaea columella has a worldwide distribution that was facilitated by the trade of aquatic freshwater plants (Cowie 2000). It is very possible this was the mode of transport for this genus to our island as there is a very active ornamental trade in the island for both plants and animals. This species is also of medical importance as

Fig. 3. Two live *Lymnaea columella.*

it is an intermediate host for the trematode *Fasciola hepatica* (Linnaeus) which is known to cause fascioliasis in livestock and sometimes in humans (Mas-Coma *et al.* 2005). As such it is important that the spread of this species is monitored closely.

Specimens of both species are stored in The University of the West Indies Zoology Museum, St. Augustine, Trinidad and Tobago under the following accession numbers: UWIZM.2011.34 – dry shells, alcohol and formalin preserved specimens of *P. diffusa,* UWIZM.2012.11 – dry shells and alcohol preserved specimens of *L. columella.*

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VIEWPOINT

The Changing Trinidad and Tobago Herpetofauna

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ABSTRACT
The Trinidad and Tobago herpetofauna is rich in species and the numbers of recognised species on the islands are expected to grow despite the extensive efforts previously made to study the fauna. Recent advances in molecular technology and cladistics form the basis for these changes. Cryptic species have been found to be quite common and many of these remain to be described from the islands. Here we note name changes and additions to the herpetofauna since 1997, comment on the likelihood that the island still contains species that have gone unrecognized by science; discuss the implications of cryptic species for conservation efforts; and suggest that education is the long-term solution to retaining the biodiversity of Trinidad and Tobago.

Key words: cryptic species, cladistics, DNA, systematics, biodiversity.

INTRODUCTION

Human knowledge is expanding at an incredible rate. Current estimates based on the growth of academic publications and an increased number of filed patents claim our knowledge base will double every 2.31 to 2.44 years, respectively (Fuller 2007). What we know today makes much of what we knew a decade ago obsolete. This is perhaps most true in scientific fields and biology is no exception. The following addresses the herpetofauna of Trinidad and Tobago as seen in the light of recent molecular studies. We discuss why the species of Trinidad and Tobago continue to be renamed, and why the number of species is likely to increase.

Trinidad and Tobago fauna continues to have names changed, species added, and species subtracted. We make predictions here on which species may be species complexes and are candidates for future name changes based on the distance of the type locality from the islands. We also discuss the importance of educating the public on the unique nature of the Trinidad and Tobago herpetofauna and the need that exists to encourage local people to take the steps necessary to conserve and restore the fauna where it is appropriate.

Carl Linnaeus' *Systema Naturae* was an attempt to organize all life forms into categories. He succeeded in recognizing a startling 5222 taxa in his 10th edition published in 1758. Some life forms were recognized and diagnosed in the text of the book, while others were in tables that illustrated Linnaeus' concept of hierarchical relationships. Classes, orders, genera, and species accounted for 4735 of Linnaeus' taxa. The remaining 487 taxa were distributed among 12 categories, such as subgenera or infrasubgenera. Some of these categories were later invalidated by the International Commission on Zoological Nomenclature, but a dozen or so subgeneric names were revalidated and are still in use (Dubois 2007).

Following Linnaeus' work, late 18th and early 19th naturalists Josephus Laurenti, Johann Schneider, Bernard Lacépède, François-Marie Daudin and Johann Spix, scrambled to apply binomial names to Western Hemisphere amphibians and reptiles in the late 18th and early 19th centuries. By the end of the 19th century, it became popular to consolidate organisms that had a similar appearance and they were often lumped together sometimes under the oldest available name, other times not. About the time that R. R. Mole and F. W. Urich started making lists of the Trinidad and Tobago herpetofauna, Albert Günther and George Boulenger were lumping species named in the early and mid-19th century together. Günther and Boulenger knew much about the world's herpetofauna, but without today's understanding of the significant role geography plays in speciation, often ignored type specimens and their localities (Adler 1989). This, paired with the late 19th and early 20th century trend to lump species, led early 20th century biologists to greatly underestimate world biodiversity. Endersby (2009) noted the terms "lumper" and "splitter" are still in use and often applied when the user disagrees with the limits of a species used by someone else. Darwin recognized that classification would eventually evolve into genealogies when naturalists learned "...to discover and trace the many diverging lines of descent..." That time has now arrived. As it turns out, splitting species is more useful in understanding modern evolutionary concepts than having broadly defined species, because it provides more detailed evidence of the evolutionary process.

Types and Type Localities

The specimen used to describe a new species is referred to as the "holotype," or "syntypes," if there is more than one specimen. Type specimens are deposited in a museum so that they can serve as a reference for the species, and researchers describing related species can examine them for comparison. When H. W. Parker of the British Museum described the dwarf marsupial frog *Gastrotheca fitzgeraldi* in 1934, the description was based upon the type specimen in the British Museum and was given a number (it is now BMNH 1947.2.22.41). The geographic location where that type specimen originated from is the type locality, and Parker clearly stated that the type of *Gastrotheca* [now *Flectonotus*] *fitzgeraldi* came from "…3000 ft. on Mt. Tucuche….Trinidad." Thus, Mt. Tucuche becomes the type locality for this species. Type specimens are important because they fix the identity of a species and type localities are important because they provide a location for the origin of the type specimen. The type locality can be re-sampled for specimens and DNA to compare to more distant populations if the type specimen is lost or, as is often the case, DNA cannot be recovered from the type specimen due to exposure to formalin used in the specimen fixation process.

Evolving Ideas and the Herpetofauna

Today, the intimate relationship between geography and biodiversity is well understood. Topography may impose barriers to gene flow or create corridors that permit it. Barriers keep individuals of a species from moving around, preventing them from reproducing with other members of that species from other populations. Barriers differ for individual species and could be as large as a river or a mountain range, or as small and seemingly simple as a small waterfall, a road, or an agricultural field. Restricting gene flow isolates populations and the results of that isolation may range from the formation of a new species to the extinction of an existing one. As topography changes over time, gene flow changes with it. Closely related species may become isolated and then reconnect, only to be isolated again. Some may hybridize and form new species or become extinct because they cannot reproduce. The goal of modern systematics is to produce a system of classification that reflects ancestry, and how a group of related species and their most recently shared ancestor link together. Any group of species and their immediate ancestor is known as a clade and most changes in scientific nomenclature today are the result of additions or subtractions of species to or from a given clade.

In the second half of the 20th century, the roots of two scientific disciplines evolved, providing powerful new tools for understanding evolution: molecular biology and cladistics. Cladistics is a way of evaluating and comparing hypotheses as to how species and groups of species are related to each other based upon shared evolutionary novelties. It allows for an examination of diverse sets of characters (morphological, behavioral, and molecular) by considering all the evidence simultaneously to produce phylogenetic trees – diagrams that show the relationships between species and groups of species. Molecular biology examines organisms at the level of genes (and their products) and makes it possible to collect much more data useful to discerning relationships between species and groups of species. Molecular sequence data – the genetic code – is the closest science has come to an unbiased assessment of evolutionary relationships. Thus, cladistics and molecular biology are at the center of reconstructing the tree of life. Computer technology has made a huge contribution to this effort, handling the large amounts of data generated by both cladistic analysis and molecular sequencing.

Linnaeus was responsible for about 23% of the names earlier applied to Trinidad and Tobago amphibians and reptiles (Murphy 1997). That proportion has now decreased slightly to 21% due to additions to the fauna and the splitting of previously named species. Thus Linnaeus' contributions to the herpetofauna can be expected to continue to decline as once-thought widespread species are divided into species with more restricted distributions and new species are found.

The Trinidad and Tobago fauna has been described as a depauperate Venezuelan fauna (Kenny 2000). There is some truth in this view. Both islands are continental and they contain a flora and fauna that had their ancestry on mainland South America. However it is a mistake to believe that the flora and fauna of the islands are just remnants of South America. By definition, terrestrial species on islands are genetically isolated, in this case by the sea that creates a barrier between Trinidad and Tobago and mainland Venezuela.

But gene isolation occurs even more specifically than at the island level. Trinidad and Tobago are full of unique and isolated tracts of land whose organisms are unable to interact with other populations of the same species. The first that comes to mind are man-made patches of now-fragmented habitat, cut off from the surrounding region by urban sprawl or agricultural lands. However, some are naturally occurring "terrestrial islands" like Trinidad's three hill ranges and Tobago's Main Ridge, all elevated terrain composed of unique habitat when compared to the lower lands surrounding them. Likewise, the species in the savanna habitats at Aripo and Erin are, or were, restricted to those grasslands by the encompassing forest.

Today we see the marine barriers to terrestrial vertebrates that isolate the islands from the mainland. But tectonic forces, historic fluctuations in sea level, altered drainage basins, climate change, and dispersal of species to the island both by natural means and human mediated transport have been at work on the flora and fauna to produce the species we see today. The flora and fauna of Trinidad and Tobago have not ceased to evolve since the islands were isolated from South America.

Widespread and Endemic Species

Nine frogs, seven lizards and eleven snakes, or approximately 19% of Trinidad and Tobago's total herpetofauna (including introduced species and questionable records) are currently considered endemic. That is, these endemics occur only on the islands and are found nowhere else in the world. Until recently, the data suggested that the other 81% was composed of more widespread species: those of Amazonian or Guyanan ancestry with distributions extending into Central and South America. However, this perspective is changing.

Recently, several studies suggest that South American frogs are much more diverse than previously thought. In fact, researchers now believe this may be the case worldwide. New frog species are being described at an exceptionally rapid rate. For the last five years, approximately one new frog has been described every three days (AmphibiaWeb 2011).

Fouquet *et al.* (2007) addressed 60 French Guyanan frog species, most considered widespread with distributions ranging throughout Guyana and Amazonia. They attempted to estimate the number of undescribed species of amphibians in this region by examining the variation in the mitochondrial 16S gene. They found that 21 of the 60 species (35%) of the geographically distant populations belong to very distinct genetic lineages that could be new species. From this they estimated that as many as 115% additional Neotropical amphibians may be expected to be discovered. Of the 400 frog species recognized from Amazonia and Guyana, 150 (37%) of them have distributions covering more than 1 million km^2 – a sizable geographic area easily capable of containing potentially cryptic, undetected species. Fouquet *et al*. (2007) suggest that the total number of species in these regions will easily approach 600, and there may be 860 total frog species for Amazonia, with the implication of South America potentially holding 4400 species of frogs (at this writing in November, 2011 AmphibiaWeb lists 6089 species of frogs on the planet).

Given Trinidad and Tobago's proximity to this diverse region, it seems probable to us that, like the nearby mainland ecosystems, these islands hold more endemic and near endemic species masquerading as widespread or Amazonian species. Furthermore, it is unlikely that these additional species are limited to frogs.

Widespread lizards and snakes are also likely candidates for being endemics or near endemics. However, widespread species do exist. Fouquet *et al*. (2007) found some widespread species that were so similar genetically, that they may have spread over South America quite recently, but the authors note that these widespread species compose the minority of cases. For example, of the recorded frog species inhabiting Trinidad, only 10 (*Rhinella marina*, *Leptodactylus fuscus*, *Leptodactylus hylaedactylus*, *Engystomops pustulosus, Scinax ruber, Sphaenorhynchus lacteus*, *Lithobates palmipes*, *Pipa pipa*, and *Hypsiboas boans*) are thought to be true widespread species also found over large areas of South America. It is important to note that these species are affiliated with either savanna, riverine, or swamp habitats. In all cases, habitats suspected allow organisms to move rapidly through large expanses of similar habitat or along corridors that connect patches of similar habitat. In the long run even this view may change; rivers change course, wetlands fill through sedimentation, and new ones form by erosion.

Endemic species in Venezuela and Trinidad and Tobago often share a common ancestor; the stream frogs of the genus *Mannophryne* are an excellent example. *Mannophryne olmonae* is found on Tobago, *M. trinitatis* is found on Trinidad, and *Mannophryne leonardi* and *M. venezuelensis* are found in Venezuela. However, as late as the 1960's all four species were lumped into the single species *Mannophryne trinitatis*. Jowers *et al*. (2011) used molecular data to show that *M. trinitatis* and *M. venezuelensis* are sister species with their most recent common ancestor at 7.28 MYA. Additionally, they described *M. leonardi*, a Venezuelan species that had been confused with *M. trinitatis.* Jowers *et al*. also showed *M. trinitatis* to be the result of vicariance, not dispersal by rafting. Thus, *Mannophryne trinitatis* and *M. venezuelensis* likely split from their shared ancestor when Trinidad separated from Venezuela in the Miocene. Undoubtedly, this is true for many of the Trinidad and Tobago species – their presence as island endemics is the result of vicariance. However, some species may well have reached the islands by dispersal from the mainland or colonization from the Lesser Antilles.

There are widespread lizard and snake species, also. Kronauer *et al*. (2005) examined the widespread turniptailed gecko, *Thecadactylus rapicauda*, and found the Trinidad and Tobago populations were more closely related to mainland populations than the Lesser Antilles populations. Gamble *et al*. (2008) found little genetic divergence in the widespread *Gonatodes humeralis*, and the divergence they did find originated relatively recently, about 1.9 MYA. They also suggest the most recent common ancestor for the two sister species of geckos, *Gonatodes ocellatus* (a Tobago endemic) and *Gonatodes ceciliae* (a near Trinidad endemic), split roughly 3.8 MYA.

Without collecting, sequencing, and comparing DNA from a variety of locations, it is difficult to know if a species is a widespread form or a complex of cryptic species. Using existing data, ruling out the known widespread species, and examining the remaining species, clues to which species may be cryptic can be had. The greater the distance between the islands and the type locality of a specific species, the more likely it is that a currently recognized species is actually a complex of cryptic species. This is based upon the simple assumption that a greater distance between two sites results in a reduced chance of genetic exchange.

This, however, is not the whole story; even species with relatively restricted distributions can be composed of unrecognized taxa. The variegated gecko, *Gonatodes ceciliae,* is a likely candidate for representing two or more species on Trinidad that are cryptic, sympatric, and syntopic. McBee *et al*. (1987) found two different karyotypes (individuals with different sets of chromosomes) living together. No one has followed up on this report, but cryptic vertebrate species living side by side is a phenomenon that has only recently been recognized (Stuart *et al*. 2006) and emphasizes the fact that biodiversity has been severely underestimated. McLeod (2010) recently reported three distinct, cryptic lineages of the Southeast Asian frog *Limnoectes khulii* living side by side at a single locality – something that researchers would have thought highly improbable, if not impossible, only a few years ago.

Predicting Cryptic Species

As explained above, it is possible to predict which allegedly widespread species are likely candidates for cryptic species complexes by investigating the distance between a type locality and a more distant collection site. Using this principle and distance measurements from Google Earth, we can apply the type localities reported in Murphy (1997) and updated by the Amphibian Species of the World website (Frost 2011) and the Reptile Database website (Utez 2011), to predict which of Trinidad and Tobago's populations are likely to contain cryptic species and require taxonomic updates.

We found 36 species with type localities greater than 800 km from Trinidad. An 800 km radius will produce a terrestrial area that is about one million km^2 the area Fouquet *et al*. (2007) predicted likely to contain undiscovered cryptic species. In reality, it may be much less. Consider the genus *Chironius*, commonly called the machete. Trinidad has three species, two are very difficult to separate from each other – these are cryptic species. Dixon *et al*. (1983) reviewed the genus; they state that *Chironius carinatus* has 12-12-8 scale rows (meaning 12 scale rows on the forebody, 12 at mid body and 8 near the vent) and that this will distinguish this snake from all other *Chironius*. However, *C. septentrionalis* (also found on Trinidad) has 12-12-8 in males and 12-12-10 in females. The ventral scale counts for *C. carinatus* are given as 108-145 and for *C. septentrionalis* as 161-196, but superficially these snakes are quite similar.

Due to cladistics, molecular biology and computer technology, the investigation of amphibian and reptile evolution is now advancing at a faster pace than at any time in history. New species will continue to be described at a rapid pace and the number of species composing the Trinidad and Tobago herpetofauna will also increase. The recently discovered hylid frog *Scarthyla vigilans* (Smith *et al*. 2011) is an excellent example. The current nomenclature of the herpetofauna of Trinidad and Tobago is provided in Table 1. Despite the work done by Boos, Downie, Kenny, and Murphy, much remains to be learned, not only about the Trinidad and Tobago herpetofauna, but about the rest of the islands' organisms as well.

SOME OVERLOOKED RECORDS FROM MUSEUMS AND FIELD NOTES

Plica plica on Tobago

This lizard has not been previously reported from Tobago. However, on 12 June, 1994 one of us (JCM) observed a large (~20 individuals) colony of these lizards in central Tobago at an abandoned sawmill. None were collected.

Two New Species of Skinks in Trinidad and Tobago

Copeoglossum aurae Hedges and Conn 2012. This species has been called: *Mabuia agilis, Mabuia aenea, Mabuya mabouia, Mabuya mabouya mabouya, Mabuya bistriata, Mabuya sloanii, Mabuya nigropunctata* by various authors over the years. It is the most frequently seen skink on Trinidad and Tobago. In 2012, Hedges and Conn demonstrated this lizard was not conspecific with any of the Amazonian skinks and named it *Copeoglossum aurae*. This species is now known from Grenada, St. Vincent, the Grenadines, Trinidad (including Huevos Island), and Tobago as well as Sucre, Venezuela.

Marisora aurulae Hedges and Conn 2012. This species has also been called *Mabuya falconensis.* In 2010, a Trinidad specimen of this skink (Fig. 1) was collected in the southern peninsula near Icacos. However, Hedges and Conn demonstrated this lizard was not conspecific with *falconensis* and named it *Marisora aurulae*. A species distributed in the southern Lesser Antilles and on Trinidad and Tobago; and known to occur on Young's Island (a satellite of St. Vincent), the Grenadines (Mayero Island, Carriacou, and Petit Bateau in the Tobago Cays), Grenada, Trinidad, and Tobago.

Epictia goudotii in Trinidad and Tobago

Peters and Orejas-Miranda (1970) reported Trinidad in the range of *Epictia* (=*Leptotyphlops*) *goudotii*; Emsley (1977) included *Epictia* (=*Leptotyphlops*) *goudotii* in his list of invalid records of snakes from Trinidad. He wrote, "…known only from Patos Island, which was politically part of Trinidad until 1942." We located two specimens of this snake with the locality data of "Trinidad" in the USNM (Fig. 2). This is the first confirmation of this snake on Trinidad.

Table 1. Changes in the names and the addition of species to the Trinidad and Tobago herpetofauna since Murphy (1997).

Name Used in Murphy 1997	Current Name and Additions	References
	Frogs	
	Family Bufonidae - True Toads	
Bufo beebei	*Rhinella humboldti* (Gallardo 1965)	Narvaes and Rodrigues 2009
Bufo marinus	*Rhinella marina* (Linnaeus)	Chaparro *et al.* 2007
	Family Centrolenidae - Glass Frogs	
Hyalinobatrachium orientale tobagoensis	*Hyalinobatrachium orientale* (Rivero)	Castroviejo-Fisher *et al.* 2008
	Family Hylidae - Tree Frogs	
Hyla microcephala misera	*Dendropsophus microcephalus misera* (Cope)	Faivovich *et al.* 2005
Hyla minuscula	*Dendropsophus minusculus* (Rivero)	Faivovich *et al.* 2005
Hyla minutus	*Dendropsophus minutus* (Peters)	Faivovich *et al.* 2005
Hyla boans	*Hypsiboas boans* (Linnaeus)	Faivovich *et al.* 2005
Hyla crepitans	*Hypsiboas crepitans* Weid-Neuwied	Faivovich *et al.* 2005
Hyla geographica	*Hypsiboas geographicus* (Spix)	Faivovich *et al.* 2005
Hyla punctata	*Hypsiboas punctatus* (Schneider)	Faivovich *et al.* 2005
Phyllodytes auratus	*Phytotriades auratus* (Boulenger)	Jowers *et al.* 2009
Added to fauna	*Scarthyla vigilans* (Solano)	Smith *et al.* 2011
Phryanohyas venulosa	*Trachycephalus typhonius* (Linnaeus 1758)	Lavilla *et al.* 2010
	Family Leiuperidae	
Physalaemus pustulosus	*Engystomops pustulosus* (Cope 1864)	Nascimento *et al.* 2005
	Family Leptodactylidae	
Adenomera hylaedactylus	*Leptodactylus hylaedactylus* (Cope)	Frost *et al.* 2006
	Family Ranidae	
Rana palmipes	*Lithobates palmipes* (Spix)	Frost *et al.* 2006
	Family Strabomantidae	
Eleutherodactylus charlottevillensis	*Pristimantis charlottevillensis* (Kaiser *et al.*)	Heinicke *et al.* 2007

Table 1 cont. Changes in the names and the addition of species to the Trinidad and Tobago herpetofauna since Murphy (1997).

Name Used in Murphy 1997	Current Name and Additions	References
Eleutherodactylus cf. *rozei*	*Pristimantis turpinorum* (Hardy)	Heinicke *et al.* 2007
Eleutherodactylus urichi	*Pristimantis urichi* (Boettger)	Heinicke *et al.* 2007
	Turtles	
	Family Chelidae	
Phrynops gibba	*Mesoclemmys gibba* (Schweigger)	McCord *et al.* 2001
	Family Testudinidae	
Geochelone carbonaris	*Chelonoidis carbonaria* (Spix)	Cei 1993
Geochelone denticulata	*Chelonoidis denticulata* (Linnaeus)	Obst 1985
	Lizards	
	Family Gymnopthalmidae	
Proctoporus shrevei	*Riama shrevei* (Parker)	Doan and Castoe 2005
	Family Dactyolidae	
Added to fauna	*Anolis wattsi* Boulenger 1894	White and Hailey 2006
	Family Scincidae	
Added to fauna	*Marisora aurulae* Hedges and Conn 2012	Hedges and Conn 2012
Mabuya bistriata	*Copeoglossum aurae* Hedges and Conn 2012	Hedges and Conn 2012
	Family Tropiduridae	
Tropidurus plica	*Plica plica* (Linnaeus)	Frost *et al.* 2001
	Snakes	
	Family Aniliidae	
Added to fauna	*Anilius scytale scytale* (Linnaeus 1758)	Boos 2001
	Family Leptotyphlopidae	
Added to fauna	*Epictia goudotti* (Dumeril and Bibron 1844)	Confirmed here
Leptotyphlops albifrons	*Epictia tenella* (Klauber 1939)	Adalsteinsson *et al.* 2009
	Family Boidae	
Corallus hortulanus cookii	*Corallus ruschenbergerii* (Cope 1867)	Henderson 1997
Epicrates cenchria maurus	*Epicrates maurus* Gray	Passos and Fernandes 2008
	Family Colubridae	
Added to fauna	*Chironius septentrionalis* Dixon, Wiest and Cei	Boos 2001
Added to fauna	*Chironius scurrulus* (Wagler)	Boos 2001
Leptophis riveti	*Leptophis stimsoni* Harding	Harding 1995
Mastigodryas boddaerti dunni	*Mastigodryas dunni* (Stuart)	Montingelli 2009
Dipsas variegate trinitatis	*Dipsas trinitatis* Parker	Harvey 2008
Added to fauna	*Erythrolamprus bizona* Jan	Boos 2001
Thamnodynases sp.	*Thamnodynastes ramonriveroi* Manzanilla and Sánchez	Manzanilla and Sánchez 2005

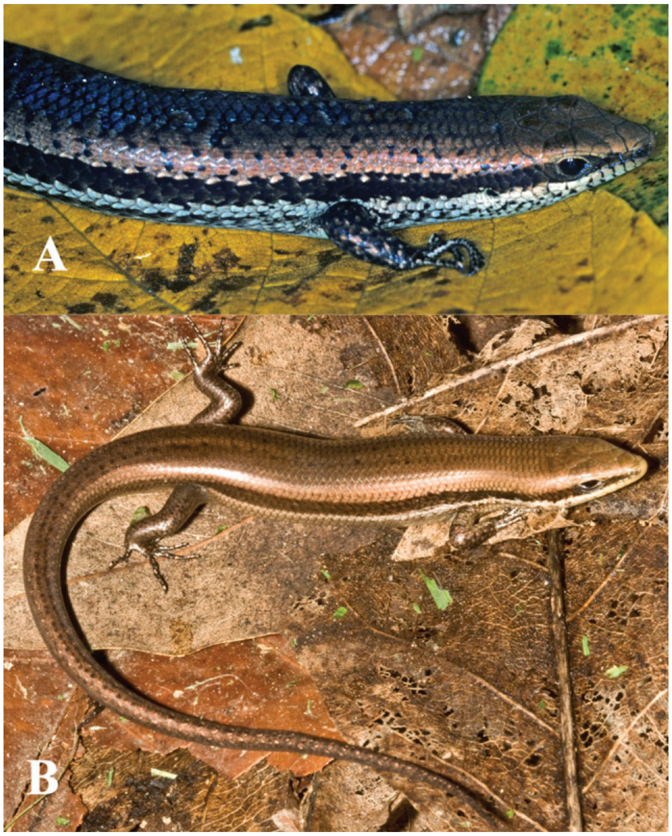

Fig. 1. Two species of Trinidad and Tobago skinks, both species are present on both islands. **A.** *Copeoglossum aurae* (previously called *Mabuya bistriata* or *M. nigropunctatus*). **B.** *Marisora aurulae* (previously called *Mabuya falconensis).*

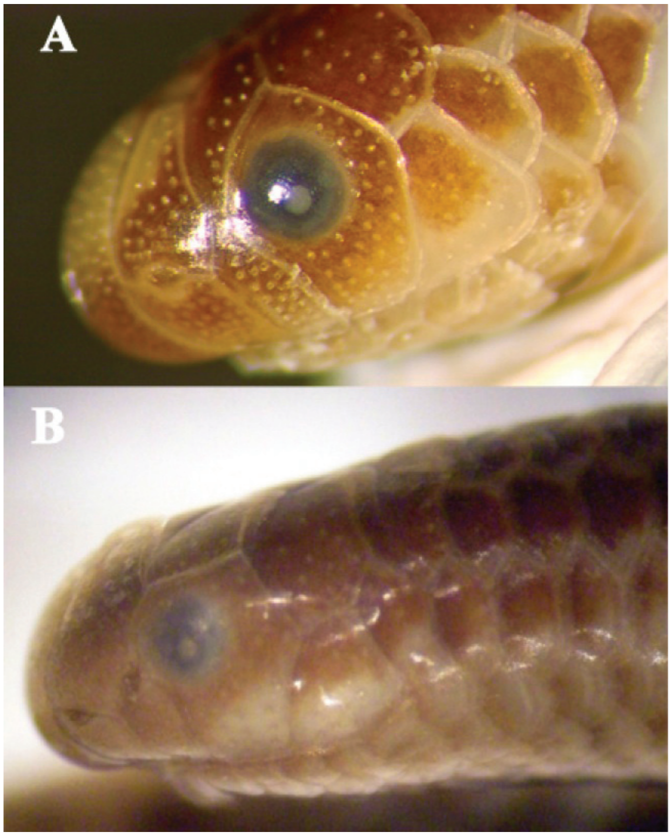

Fig. 2. A comparison of the two species of Trinidad thread snakes. **A.** The relatively well-known *Epictia tenella* (formerly called *Leptotyphlops tenella*). **B.** A specimen of *Epictia goudotti* not previously reported from Trinidad.

IMPLICATIONS FOR CONSERVATION AND NATURAL HISTORY EDUCATION

Amphibians and reptiles are among the most endangered of all vertebrate species (Gibbons *et al*. 2000; Stuart *et al*. 2004). Of the species monitored by the IUCN, more than 30% of the amphibians and reptiles are considered threatened, and these are just the ones we know about. The Center for Biological Diversity recently started a campaign titled, 'The Amphibian and Reptile Extinction Crisis.'

In addition to contributing to climate change, over the last few hundred years humans have dramatically fragmented the 'original' habitat of Trinidad and Tobago. Gone are most of the lowland forests – making much of both islands uninhabitable for the forested species that once inhabited the region. Patches of forests in the Northern, Central and Southern Ranges on Trinidad and the Main Ridge of Tobago are now isolated and in the process of being divided into even smaller parcels by human actions including road building, agriculture, and urban sprawl. Habitat fragmentation makes it difficult for many species to maintain viable populations and therefore increases the extinction rate.

Recently, Hailey and Cazabon-Mannette (2011) assessed the conservation of the islands' herpetofauna and noted that Trinidad and Tobago are unique amongst other Caribbean islands because they were developed relatively late in the European colonial period and the delayed population and agricultural growth left relatively large areas of original habitat. Further, they found industrial development is a major feature of current economic growth on Trinidad, while Tobago is more like the typical Caribbean island, without major industrial development. They see future development exacerbating the habitat loss that has already occurred: pollution from industrialization, urbanization, transport links, and quarrying (siltation of rivers as well as habitat loss); agriculture pesticides; and the salinization of water from the oil and gas industry. All of these pose major threats to the well-being of the islands' herpetofauna. They also discuss forestry practices, climate change and the frog fungus disease, chytridiomycosis, which is present on the islands, but not yet known to have caused deaths.

Protecting the valuable biodiversity resources of Trinidad and Tobago should be considered an immediate problem and given the highest priority. While legislation that regulates development may help in the short-term, the long-term solution to this problem is education. If the next generation values the environment and its diversity more than the current generation, things can improve. Protecting the existing gene pools until this can be accomplished is important and a goal worthy of national attention.

Natural history can be considered a means of exploring the stories of nature by attending to and focusing on the natural world. Sadly, public education of the subject matter and the perspective it brings is absent from most modern educational systems in all countries and is one of the reasons why the environment, the world's biodiversity, and humanity at large are threatened by impending ecological disasters. While the study of natural history focuses human attention on nature, most current educational systems center on programs that decouple humans from nature. Changing the worldwide perspective to help humans understand how they, the non-human organisms, and the landscape share in a single, interactive system could literally save the planet. This does not mean changing the subjects taught in schools: language, math, social studies, and science can all be taught with a natural history focus. Integrating natural history education into school curricula should be the mission and passion of groups like the Trinidad and Tobago Field Naturalists' Club.

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Ninth Report of the Trinidad and Tobago Rare Birds Committee: Rare Birds in Trinidad and Tobago 2011

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The Trinidad and Tobago Rare Birds Committee (TTRBC) was established in 1995 with the principal aim to assess, document and archive the occurrence of rare or unusual birds in Trinidad and Tobago. The Committee has now assessed all records submitted during 2011. In all, 54 records were adjudged, representing 42 different species. No additional species have been added to the Official List of the Birds of Trinidad and Tobago, the running total remains at 471 species. Of the submissions assessed, in only five cases did the Committee find the identification inconclusive. The records tabulated below follow the nomenclature and taxonomic order of the American Ornithologists Union South American Checklist; January 2012.

The Committee comprises the following members: Martyn Kenefick (Secretary), Geoffrey Gomes, Floyd Hayes, Bill Murphy, Courtenay Rooks and Graham White.

Archived records including photographic submissions are held at 36 Newalloville Ave., San Juan. Previous reports of this Committee were prepared by Hayes and White (2000); White and Hayes (2002) and Kenefick (2005, 2007, 2008, 2009, 2010, 2011).

Members of the TTRBC are aware that a number of other rare birds are found each year in Trinidad and Tobago and urge finders not only to report their sightings to us, but to document same. In particular, a Double-striped Thick-knee was apparently seen by many observers during late September in Tobago. A recently revised list of those species considered by the TTRBC, together with the Official List of the Birds of Trinidad and Tobago and details of all accepted records by the Committee, can be accessed from our new website at http://rbc.ttfnc.org

RECORDS ACCEPTED

Two adult **White-faced Whistling-Ducks, *Dendrocygna viduata,*** were found on Caroni Rice Project on 3 July, 2011 (MK, DS). Whilst previously recorded annually at this site, difficulty of vehicular access has restricted the number of sightings of this scarce austral wanderer in recent years. On 15 October, 2011 a flock of 14 were photographed in South Oropouche (KS, CC). This is the first documented sighting for south Trinidad.

An adult male **Muscovy Duck, *Cairina moschata,*** flew high over South Oropouche on 12 February, 2011 (MK, GW) whilst at Icacos, two males were photographed on 23 May, 2011 (KS) with one present at the same location on 28 November, 2011 (KS). There have now been nine different sightings, involving probably 20 different birds, in the last three years. All but one have been in the wetlands of south-west Trinidad.

Three **Lesser Scaup, *Aythya affinis,*** in female or immature plumage were photographed at Lowlands, Tobago on 15 February, 2011 (MKe). This species has now been found at this site in three of the last five years.

Breeding of **Masked Duck, *Nomonyx dominicus,*** in Tobago was proven for the first time in 2011 when two pairs successfully reared at least 10 chicks with a further male still in breeding plumage on an adjacent wetland. Two different clutches of chicks were observed on 15 February and 24 March, 2011 (GG, MK, MKe BM *et al.*).

An adult **Green Heron, *Butorides virescens,*** was photographed close to Arima on 1 May, 2011 (DW). Whilst a common resident in Tobago, this is the first documented sighting in Trinidad since the inception of the TTRBC 17 years ago.

An immature **Gray Heron, *Ardea cinerea,*** was photographed at Bon Accord sewage lagoons, Tobago on 19 November, 2011 (FM, AS). With only two records in the previous century, there have now been eight sightings since 2001. This is likely the result of increased observer awareness of identification features especially of non-adult *Ardea* herons.

The **Purple Heron, *Ardea purpurea,*** first found in February, 2010 was still present at Bon Accord sewage lagoons, Tobago until late May, 2011 at least (many observers).

A juvenile **Reddish Egret, *Egretta rufescens,*** was photographed inside Caroni Swamp on 2 June, 2011 (RJ, DR *et al.*). Whilst this species is still undoubtedly rare, it has now been found in Trinidad in three of the last four years.

An adult **Jabiru, *Jabiru mycteria,*** was photographed close to Mon Desir Village on 9 September, 2011 (TM). This remains an extremely rare wanderer from mainland South America with just three previous records in the last 16 years.

An adult **Crane Hawk, *Geranospiza caerulescens,*** was photographed in trees close to the picnic site at Carli Bay on 16 November, 2011 (MK, FM). This species was first found in Trinidad as recently as 2001, and has been documented in every year since, except one.

An adult **Rufous Crab-Hawk, *Buteogallus aequinoctialis,*** was photographed perched on a utility pylon at Icacos on 27 March, 2011 (DS). This is likely to be one of the adults seen in exactly the same area during 2010. Several sightings of two adults and a juvenile during September and early October, 2011 at Carli Bay (NL, SP, DS *et al*.) suggest that this species now breeds in Trinidad.

An adult **Great Black-Hawk, *Buteogallus urubitinga,*** photographed at Cat's Hill on 18 June, 2011(KS, DS, NL) was the only documented sighting in Trinidad during the year. The species remains a rare resident in Trinidad, more regularly found in eastern Tobago.

An adult **Black-collared Hawk, *Busarellus nigricollis,*** was photographed soaring over Rousillac on 16 November, 2011 (KS). This is the first sighting of this occasional wanderer from the South American mainland since 1998.

An adult **Black Hawk-Eagle, *Spizaetus tyrannus,*** was seen soaring high over the Arima Valley from Asa Wright Nature Centre on 6 May, 2011 (ER *et al.*). Whilst this is the only documented sighting, we are aware of verbal reports indicating that this species has been seen in the valley on a number of occasions during the year.

Numerous reports of **Crested Caracara, *Caracara cheriway,*** in the Manzanilla and eastern Nariva coastline during the year included a family group of two adults and three juveniles on 6 October, 2011 (BM *et al.*) further supporting our belief of local breeding. Elsewhere, an adult was photographed at La Brea on 4 October (SP).

Rufous-necked Wood-Rail, *Aramides axillaris* is a species occasionally encountered in Caroni swamp (SM per. comm.). On 9 October, 2011, a juvenile was photographed alongside Drain No 9 (BM *et al.*). This is the first photograph of juvenile plumage to be submitted to TTRBC.

An **American Oystercatcher, *Haematopus palliates,*** was photographed amongst the high tide roost at Orange Valley on 19 June, 2011 (NL) and was still present the following day. Another individual was photographed at the same site on 16 November, 2011 (MK, DS). Despite these being the first sightings in Trinidad since 1997, the likelihood of only one bird being involved at this well watched site is unlikely.

A **Hudsonian Godwit, *Limosa haemastica,*** was found on sewage ponds within the Lowlands complex, Tobago on 26 October, 2011 and was still present the following day (NG, MK). Whilst this species is a fairly regular southbound migrant in the wetlands of Trinidad, this is the first Tobago sighting for many years.

Red Knot, *Calidris canutus,* is an uncommon passage migrant through Trinidad and Tobago and, as such, records are not normally considered by TTRBC. However, during mid to late September, 2011, several birds amongst a feeding flock of 12 at Orange Valley were seen to have colored "flags" attached to their legs (DS). Subsequent investigation has proved that not only were these individuals originally tagged in New Jersey, USA; but they have been documented 7000 km south at their wintering grounds in southern Argentina.

Two **Buff-breasted Sandpipers, *Tryngites subruficollis,*** were photographed on a flooded sports field at Penal on 15 October, 2011 (KS). This species has been recorded in eight of the last 11 years. All southbound migrant records have occurred during the period 17 September - 28 October.

An **Upland Sandpiper, *Bartramia longicauda,*** was photographed east of Woodland Settlement on 31 August, 2011 (KS). This is the earliest southbound record since the formation of the TTRBC. Another was found on Lowlands golf course, Tobago 25-26 October, 2011 (NG, MK).

A first winter plumaged **Black-headed Gull, *Chroicocephalus ridibundus,*** was found at Orange Valley on 22 January, 2011 (NL). It remained in the area until 8 May, 2011 at least (DS, MK *et al.*), by which time it had partially moulted into breeding plumage. Since 2000, we have averaged one documented sighting per year, all from the Trinidad west coast mudflats.

One, possibly two, **Franklin's Gulls, *Leucophaeus pipixcan,*** were amongst the high tide gull roost at Brickfields 24-25 January, 2011 (MK, DS *et al.*). There have now been nine birds recorded since 1998. Whilst still undoubtedly rare, and only ever found on the west coast of Trinidad, their true abundance is probably overlooked amongst the large flocks of wintering Laughing Gulls.

Up to four second winter plumaged **Ring-billed Gulls, *Larus delawarensis,*** and a further adult were regularly seen at the high tide roost at Orange Valley between 11 January and 9 April, 2011 (DS, TM, NL *et al.*). This is the highest annual total on record, with just four birds recorded from 2000 to 2010.

A non-breeding plumaged **Caspian Tern, *Hydroprogne caspia,*** was photographed at Orange Valley on 15 November, 2011 (NL, DS *et al.*). It was still present at the high tide roost two days later. The only other recent record of this species was on 24 November, 2005.

At least two pairs of **Scaled Doves, *Columbina squammata,*** were found on a private estate on Monos Island on 1 May, 2011 (ER). Two birds were still present on 29 May (GW, MK). Another pair was photographed at the Pitch Lake on 17 November, 2011 (SP). There are now just four records for Trinidad with previous sightings in 1926 and 1996. However, neither of these sites are regularly visited by birdwatchers and the current data may not reflect the true status of this species.

An adult male **Blue Ground-Dove, *Claravis pretiosa,*** was photographed and two others seen at Granville on 18 November, 2011 (NL, FM). Whilst this species is undoubtedly still a rare resident, few birders ever visit this site.

A **Scaly-naped Pigeon, *Patagioenas squamosa,*** was seen flying over Little Tobago Island on 4 October, 2011 (BM *et al.*). Since first being found as recently as 2005, all records to date have been from Tobago and Little Tobago. There are now undocumented reports of a small resident population on the island.

A **Dark-billed Cuckoo, *Coccyzus melacoryphus,*** was found on the western side of Nariva Swamp, accessed from Plum Mitan Village on 24 July, 2011 (MK, GW). This is the fifth record in the last 16 years; all records are from July and August.

A **Mottled Owl, *Ciccaba virgata,*** was photographed in an area of deciduous woodland close to Cat's Hill on 31 May, 2011 (KS). On subsequent visits during June and July, perhaps three different birds were heard calling and one seen on two different dates.

Two immature **Cliff Swallows, *Petrochelidon pyrrhonota,*** were found feeding amongst a flock of Barn Swallows at Bon Accord sewage lagoons on 2 October, 2011 (BM *et al.*), with one still present on the 28 (MK). This location is proving to be particularly reliable for this species with sightings in six out of the last seven years in March and from late September to December.

A male **Gray Seedeater, *Sporophila intermedia,*** was photographed at Carli Bay on 6 November, 2011 (NL). Its wary nature could indicate a wild bird, however, it is impossible to rule out a possible escape from captivity.

At least two male **Lesson's Seedeaters, *Sporophila bouvronides,*** were photographed in Cat's Hill forest on 25 May, 2011 (KS). One was still singing until 31 May at least (MK, KS *et al.*). Whilst all *Sporophila* seedeaters are still rare in Trinidad, this is the second year in recent times that this species has been found in forested South Trinidad.

A flock of approximately 10 **Lined Seedeaters, *Sporophila lineola,*** including just one adult male were seen and photographed in dry agricultural fields at South Oropouche on 31 August, 2011(KS). First found in Trinidad as recently as 2007, all documented sightings have been either from South Oropouche or Nariva Swamp and fall during the period mid-August to early October.

A small flock of six **Yellow-bellied Seedeaters, *Sporophila nigricollis,*** were found on Monos Island on 1 May, 2011 (ER *et al.*), with at least one female still present on 29 May. A pair successfully nested in Lopinot Valley (GW). This is the first documented breeding record for mainland Trinidad in many years.

An adult male **Summer Tanager, *Piranga rubra,*** was photographed along the Blanchisseuse Rd. on 6 February, 2011 (MK, MKe), and on 10 December, 2011 a bird in female or immature plumage was photographed at Carli Bay (KS, DS, NL). One or two individuals are recorded almost annually, however, the true status of this winter visitor may be obscured due to its plumage similarity with the resident Hepatic Tanager.

A belated report of an immature male **Rose-breasted Grosbeak, *Pheucticus ludovicianus,*** photographed in St. Mary's Village, South Oropouche on an undocumented date in 2007 (TM). This is the first record of this species in Trinidad away from the Northern Range. More expected, was a female feeding in a *Trema* tree at Asa Wright Nature Centre on 3 December, 2011 (MK, LE *et al.*).

An immature female **Chestnut-sided Warbler, *Dendroica pensylvanica,*** was seen briefly at the entrance to Asa Wright Nature Centre on 16 January, 2011 (MK). This is the fifth record in the last 16 years, with all sightings between 19 December and 28 February.

A flock of at least 30 **Bobolink, *Dolichonyx oryzivorus,*** were found feeding on guinea grass at Caroni Rice Project on 11 October, 2011 (MK, DS, GW). Flocks of Bobolink have now been seen on 15 occasions since 2000; eight times at this location. All but one sighting are from 1 October to 28 December.

An adult male **Lesser Goldfinch, *Carduelis psaltria,*** was photographed on 30 June, 2011 on Mt. St. Benedict (MMC). First found in Trinidad in 2005 and seen in just two subsequent years, all documented records come from this one location.

INCONCLUSIVE RECORDS

The following submissions were considered inconclusive: Hook-billed Kite, *Chondrohierax uncinatus;* Double-striped Thick-knee, *Burhinus bistriatus;* Eurasian Collared Dove, *Streptopelia decaocto;* Striped Owl, *Pseudoscops clamator* (Tobago); Cliff Swallow, *Petrochelidon pyrrhonota* (Tobago).

SOUTH AMERICAN CLASSIFICATION COMMITTEE

For ornithological classification, Trinidad and Tobago are considered part of South America and, consequently, we contribute to the Official South American Checklist compiled and maintained by the South American Classification Committee (SACC). Their criteria for record acceptance of a new species to the region is far stricter than that adopted by the TTRBC. They insist on photographic evidence or a specimen.

Currently, there are seven species, accepted by the TTRBC but not documented elsewhere in South America, where no such photographic evidence has been ar-


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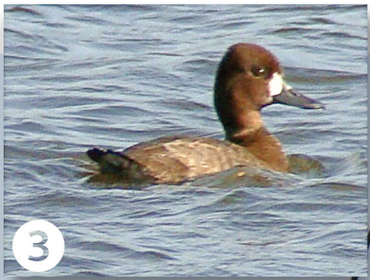
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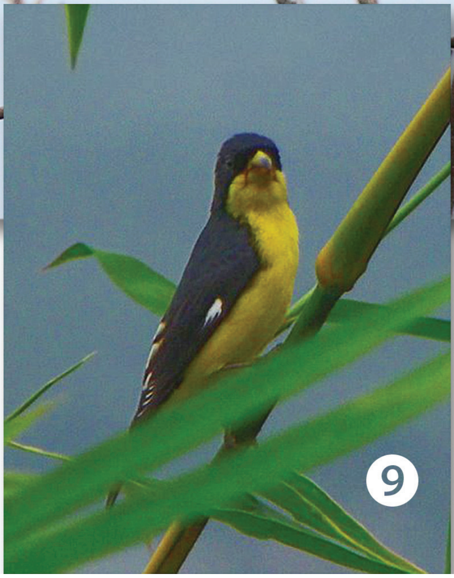
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chived. The species involved are as follows:

Snow Goose, ***Chen caerulescens*****,** sightings December, 1975 and December, 1984.

Northern Gannet, ***Morus bassanus,*** seen off north-east Tobago November, 1991 and again in August, 2009.

Common Ringed Plover, ***Charadrius hiaticula,*** single bird mist-netted in October, 1962.

Spotted Redshank, ***Tringa erythropus,*** single bird in Tobago February, 1983.

Common Greenshank, ***Tringa nebularia*****,** two different sightings in south-west Tobago July, 1977, and Waller's Field in 1987.

White-eyed Vireo, ***Vireo griseus,*** single record at Buccoo Marsh, Tobago January, 1998.

Red-winged Blackbird, ***Agelaius phoeniceus,*** one close to Caroni Swamp from June, 1980 to mid 1981.

If anyone has photographic evidence of any of the above, we would be delighted to hear from you.

NOMENCLATURE CHANGES

Part of the mission statement of the SACC is to create a standard classification, with English names, for the birds of South America. This is subject to constant revision by the proposal system to allow incorporation of new data. As a result, the following nomenclature change was made in 2011:

* **Masked Cardinal,** ***Paroaria nigrigenis,*** (formerly Red-capped Cardinal). Birds found with extensive black eye-masks and red triangular throat patches have been elevated to species rank.

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Legends to Plate

1. Franklin's Gull, Brickfield, 25 January, 2011. Photo: Dave Smith.
2. Masked Duck, Lowlands Tobago, February, 2011. Photo: Jan Willem Stefferaar.
3. Lesser Scaup, Lowlands Tobago, 15 February, 2011. Photo: Matt Kelly.
4. Scaled Dove, La Brea, 17 November, 2011. Photo: Sanjiv Parasram.
5. Crane Hawk, Carli Bay, 16 November, 2011. Photo: Fayard Mohammed.
6. Upland Sandpiper, Woodland, 31 August, 2011. Photo: Kris Sookdeo.
7. Rufous Crab-Hawk, Icacos, 27 March, 2011. Photo: Dave Smith.
8. American Oystercatcher, Orange Valley, 19 June, 2011. Photo: Nigel Lallsingh.
9. Lesser Goldfinch, Mount St. Benedict, 30 June, 2011. Photo: Miguel MC. ??

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