EcoCARE Pacific Trust
health, environment and education

University of Canterbury/EcoCARE Pacific Trust

School of Biological Sciences

High School Science Competition

Acknowledgements

The School of Biological Sciences and EcoCARE Pacific Trust would like to thank; the Government, high schools and people of Tonga for allowing this competition to go ahead. We would also like to thank; Christchurch (NZ), and Tonga Rotary Clubs for their support, Mermaid Beach Rotary (Queensland) for donating microscopes, Christchurch City Council for donating computers and the University of Canterbury International Affairs Department for pens and Concise Oxford English Dictionaries. We would like to acknowledge Air New Zealand for free freight and the hard work of the Ministry of Education in Tonga in particular Minister Hon. Tevita Hala Palefau and the Ministry of Education for encouraging schools to participate and for handling logistical matters in Tonga.

EcoCARE Pacific Trust
health, environment and education

Table of Contents

Introduction

The University of Canterbury's School of Biological Sciences/Tongan Ministry of Education/EcoCARE Pacific Trust high school science competition offers students an excellent opportunity to improve their personal skills and to win some excellent prizes for themselves and for their schools.

Information and education are some of the key components to creating a better world for all and at the University of Canterbury we place significant emphasis on research, education and sustainable development.

Since 2005 the School of Biological Sciences and EcoCARE Pacific Trust have developed a collaborative relationship to foster scientific research and educational outreach programs in the Kingdom of Tonga. This relationship has evolved to a point where today the School of Biological Sciences and EcoCARE are happy to offer high school students throughout Tonga the opportunity to compete for prizes in the SBS/EcoCARE Science Competition.

The UC/EcoCARE Science Competition has been created to foster academic excellence, interest in local Tongan environmental issues and to develop the tools required for scientific research. In recognition of students achievements students and teachers are offered a number of prizes to reward that excellence.

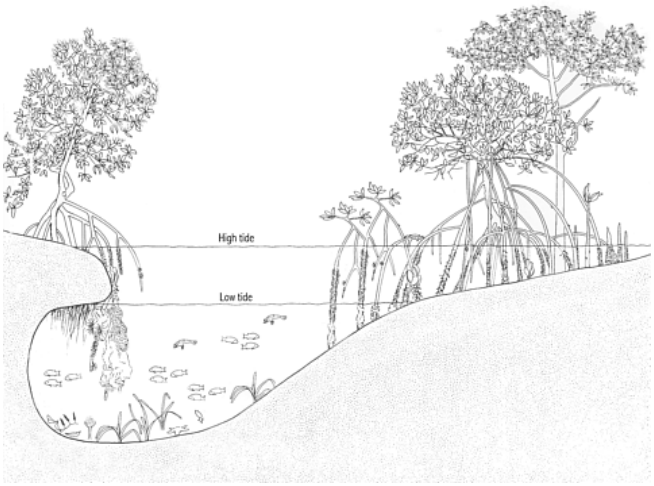
Tongan high school students are encouraged to identify local issues and to investigate those issues in a scientific manner. The research projects should culminate in the form of scientific report being presented for assessment by SBS/EcoCARE.

Project Ideas

Try to find a local or national environmental issue and topics that you find interesting. Projects could relate to pollution, waste management, resource management, deforestation, invasive species, and rare endangered plants of economic and medicinal value, diets, plant identification. Students could create plant and animal keys, produce a herbarium and interview elders regarding traditional use and so on.

We have given you a bit of information below and are happy to assist with suggestions if you would like to contact us by email.

Mangrove deforestation/restoration:



Until recently mangrove forests have been classified by many governments and members of the public as useless swamps or “wastelands”. This erroneous designation has made it easier to exploit forests as cheap and unprotected sources of land for development (Nga *et. al*., 2005).

The sustainability of coastal and marine resources and ecosystems is plummeting. Coastal zones currently provide living space for some 55% of the world’s population (Nga *et. al*., 2005; Ryder & Miller 2005**)**. Humans draw heavily on coastal and marine ecosystems for food including aquaculture and shrimp farming, construction sites for urban and industrial uses, transportation, recreational and tourism uses and waste disposal (Lee, 1999). The potential impact of the degradation of coastal and marine ecosystems on communities, human health, food security, biodiversity conservation, and local economies is enormous and will increase if nothing is done (Lee, 1999).

In tropical areas, mangrove forests are vital for healthy coastal ecosystems. Mangrove leaf-litter detritus provides a principal source of nutrients for the trophic food web and juvenile fisheries (Lee, 1999; Middleton and McKee, 2001). Mangroves are characterised by particularly high productivity of organic matter (leaf litter input averages 10 ton/ha per year), in spite of relatively low standing biomass (average 150 ton/ha) (Proffitt and Devlin, 2005). Often exposed to high-energy systems, mangroves provide protective habitat as spawning, nursery, and feeding grounds for juvenile fish, crabs, shrimps and mollusks (Nga et. al., 2005). Estimates indicate that nearly 90% of all marine organisms spend some portion of their life cycle within mangrove systems (Proffitt and Devlin, 2005). Mangroves are also prime nesting sites for hundreds of bird species (Lee, 1999).

Ryder and Miller (2005) suggest that the protective mangrove buffer zone also helps to minimise damage to property and loss of life from storms. Naturally resilient, mangrove forests are now being lost through human encroachment. Mangrove forests are among the most threatened habitats on Earth, disappearing at an alarming rate, with little public notice. Mangrove forests are disappearing as a result of extraction, charcoal and timber industries have also severely impacted mangrove forests, as have other coastal developments (Proffitt and Devlin, 2005).

Suggestions:

1. What species of Mangrove are in your area? What is their distribution?
2. Is mangrove destruction taking place?
    a. Are mangroves being impacted by natural or human influences?
    b. What are people doing to the mangroves and why?
    c. What do people use mangroves for (traditionally and in modern times)?
3. Bio-diversity and species richness:
    a. What is the abundance and diversity of species of animal?
        i. Invertebrates (marine and terrestrial)
        ii. Fish
        iii. Birds
    b. What is the abundance and diversity of species of plant
4. Storm mitigation:
    a. How much land has been lost in areas where mangroves have been deforested?
    b. Begin a mangrove restoration project;
        i. Is land being reclaimed where mangroves have been planted?
        ii. Is there an increase in bio-diversity and species richness?
5. Nutrient cycling:
    a. How much organic material falls to the ground and into the sea?
    b. How is that material processed?
    c. How much of this matter is processed in a given time?

References:

LEE S.Y. **1999**. Tropical mangrove ecology: Physical and biotic factors influencing ecosystem structure and function. *Austral Ecology*, **24**, 355-366

Middleton B. A., McKee K. L. **2001.** Degradation of mangrove tissues and implications for peat formation in Belizean island forests. *Journal of Ecology* **89**: 818–828

Nga B.T., Tinh H.Q., Tam D.T., Scheffer M., Roijackers R. **2005.** Young mangrove stands produce a large and high quality litter input to aquatic systems. *Wetlands Ecology and Management* **13**: 569

Proffitt C. E., Devlin D. J. **2005.** Long-term growth and succession in restored and natural mangrove forests in Southwestern Florida. *Wetlands Ecology and Management* **13**: 531

Ryder D. S., Miller W. **2005.** Setting goals and measuring success: linking patterns and processes in stream restoration. *Hydrobiologia* **552**: 147

Coconut crab;

The coconut crab is a type of hermit crab that can grow to gigantic proportions. It is the largest terrestrial arthropod in the world (Grubb, 1971). Most hermit crabs live their entire lives inside the shells of other sea creatures, to protect their soft bodies from predators, but unlike other hermit crabs, only very small coconut crabs use the shells of other crabs to protect their soft-skinned abdomens as they develop (Held, 1963). Once they reach juvenile status, they abandon those shells and their abdomen develops a hard exoskeleton over the rest of their bodies. This hard skin protects the crab, reduces water loss, and continues to grow along with the crab (Held, 1963). Coconut crabs can grow to as large as a meter in size (Grubb, 1971).

Although most other crabs live near and swim in water, the coconut crab cannot swim and even small specimens will drown in water (Coombs *et. al*., 1992; Grubb, 1971). But this gigantic crustacean is well adapted to living on land (Greenway and Morris, 1989). It has long strong legs, and large muscular claws that are so powerful they can lift heavy objects such as coconuts and vegetation weighing several pounds (Grubb, 1971). The large claws are used for husking coconuts and opening the shell to eat the flesh, which explains why the species is called the coconut crab.

It is also called the "palm thief" or "robber crab," because some people have claimed that coconut crabs steal shiny objects such as silverware and pans from houses and tents (Greenway *et. al*., 1990). The coconut crab also has various local names among the islands where it lives, such as "ayuyu" on Guam, and "kaveu" or "unga" in the Cook Islands. Some people call the coconut crab a "taotaomo'na" because they think the crab might be an illusion brought about by ancestral spirits called the *taotaomo'na* (Taylor *et. al*., 1993).

Taylor *et. al*. (1993) suggest that coconut crabs are also different from other crabs in that they use a special organ called a branchiostegal lung to breathe. This organ is one of the most significant adaptations of the crab to its habitat, because the way it works is something between gills and lungs.

Suggestions:

1. How many and what size are they (measure across their carapace).
2. Where did you find them (in forested areas, on sand beaches, how far from the sea, etc.).
3. Are they nocturnal (did you find them at night or during the daytime).
4. What is the coconut crabs diet?
5. Are the coconut crab preyed upon (by what, how significant is this predation).
6. What role does the coconut crab play in Island ecology
7. Coconut crabs are supposed to be found on many islands throughout the Indian and Pacific Oceans. If there are no coconut crabs on your island, why do you think this might be?
8. Since human habitation of the islands began some 2000-3000 years ago, island people have been eating coconut crabs:
    a. Does the coconut crab have a place in your society?
    b. How is this unique creature celebrated by Tongan society?
    c. Are there special ceremonies for the coconut crab?

References:

Grubb, P. **1971.** Ecology of terrestrial decapod crustaceans on Aldabra. *Philosophical Transactions of the Royal Society: Biological Sciences*. **260**: *411-416*.

Held, E. E. **1963.** Moulting behaviour of *Birgus latro. Nature*, **200**: *799-800*.

Combs, C. A. N., Alford, A., Boynton, M. Henry, R. P. **1992**. Behavioural regulation of haemolymph osmolarity through selective drinking in land crabs, *Birgus latro* and *Gecarcoidea lalandii*. *Biological Bulletin* **182:** *416-*.

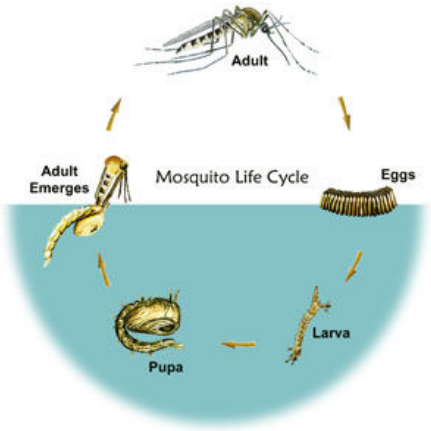
Greenaway, P., Morris, S. **1989**. Adaptations to a terrestrial existence by the robber crab *Birgus latro*. III. Nitrogenous excretion. *Journal of Experimental Biology* **143**: *333-*.

Greenaway, P., Taylor, H. H., Morris, S. **1990**. Adaptations to a terrestrial existence by the robber crab *Birgus latro*. VI. The role of the excretory system in fluid balance. *Journal of Experimental Biology* **152**: *505*

Morris, S., Taylor, H. H., Greenaway, P. **1991**. Adaptations to a terrestrial existence in the robber crab *Birgus latro* L. VII. The branchial chamber and its role in urine reprocessing. *Journal of Experimental Biology* **161**: *315*

Taylor, H. H., Greenaway, P., Morris, S. **1993**. Adaptations to a terrestrial existence in the robber crab *Birgus latro* L. VIII. Osmotic and ionic regulation on freshwater and saline drinking regimens. *Journal of Experimental Biology* **179**: *93-113*

Mosquito ecology:



Mosquitoes are one of the most important vectors of disease globally. Currently, more than 2000 mosquito species have been identified worldwide, many of which are known vectors of human disease (Spielman and D'Antonio, 2001). Mosquito-borne diseases pose a major threat both to human populations and to the diversity of indigenous fauna throughout the world and are of particular concern in developing nations of the South Pacific where the ecology and distribution of mosquitoes is only partially documented (Hales *et al.,* 1999).

In Tonga, outbreaks of Dengue occurred in 1974, 1975, 1998 and 2003, causing several fatalities (Gubler *et al.,* 1978; Muto, 1998; WHO, 2006). Furthermore, a number of mosquito species known to be vectors of Dengue fever,West Nile virus and Ross River virus (e.g. *Aedes aegypti* (Linnaeus) and *Ae. nocturnus* (Theobold)) have been previously reported in Tonga (Belkin 1962). Many of the mosquito-borne diseases can have dramatic effects on endemic fauna, as well as on human health (Atkinson *et al.* 1995).

The introduction of *Culex* mosquitoes to Hawaii in the early 19th century was believed to be responsible for the establishment of avian pox virus and malaria (*Plasmodium relictum* Grassi & Feletti) in Hawaiian forest bird populations (Atkinson *et al.* 1995). Moreover, some native birds may be more susceptible to introduced diseases and have a significantly poorer survival rate than introduced birds (van Riper & van Riper 1985; Atkinson *et al.* 1995). Mosquito-borne diseases therefore may represent a serious threat to both human health and regional biodiversity.

Suggestions

1. What is known about the mosquito life cycle?
2. What is the species diversity and richness of mosquitoes are in your area?
3. How do mosquitoes impact on every day life?
    a. How many people get ill?
    b. Are animals affected by mosquito borne diseases?
    c. What diseases are being carried by mosquitoes?
4. What could you do to alleviate the mosquito problem in your area?

References:

Atkinson, C. T., Woods, K. L., Dusek, R. J., Sileo, L. S., Iko, W. M. **1995**. Wildlife disease and conservation in Hawaii: pathogenicity of avian malaria (*Plasmodium relictum*) in experimentally infected Iiwi (*Vestiaria coccinea*). *Parasitology* **111:** S59–S69.

Belkin JN. 1962. *The Mosquitoes of the South Pacific (Diptera, Culicidae)*, Vols 1 & 2. University of California Press, Berkley, USA. Edwards FW. 1926. Mosquito notes – VI. *Bulletin of Entomological Research* **17**, 101–131.

Gubler, D. J, Reed, D., Rosen, L., Hitchcock, J. R. **1978**. Epidemiologic, clinical, and virological observations on dengue in the kingdom of Tonga. *American Journal of Tropical Medical Hygiene* **27:** 581–589.

Hales, S., Weinstein, P., Souares, Y., Woodward, A. **1999**. El Niño and the dynamics of vectorborne disease transmission. *Environmental Health Perspectives* **107:** 9.

Harding, J. S., Brown, C., Jones, F., Taylor, R. C. **2007**, Distribution and habitats of mosquito larvae in the Kingdom of Tonga, *Australian Journal of Entomology* **46:** 342-348.

Muto R. **1998**. Summary of dengue situation in WHO Wester Pacific Region. *Dengue Bulletin* **22**, 000–000.

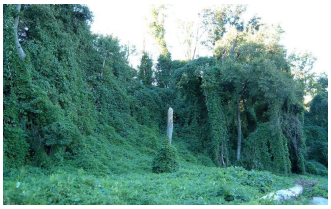
van Riper, C. III, van Riper, S. G. **1985**. A summary of known parasites and diseases recorded from the avifauna of the Hawaiian Islands. In: *Hawaii's Terrestrial Ecosystems: Preservation and Management* (eds Stone CP & Scott JM), pp. 298–371. Cooperative National Park Resources Studies Unit, University of Hawaii, Honolulu, USA.

Spielman A & D'Antonio M. **2001**. *Mosquito: A Natural History of Our Most Persistent and Deadly Foe*. Faber & Faber, London, UK.

World Health Organization (WHO). **2006**. *Xxxx.* [Cited 00 Xxx 0000.] Available from URL: http://www.wpro.who.int/countries/ton/health_situation.htm

Invasive species:




Many invasive species of plants and animals aggressively colonise new land masses so that these species become dominant in their new geographical areas (Ricklefs & Schluter 1993; Terborgh *et al.*, 2001). Benign members of their original habitats, invasive species include plants, mammals, birds, fish, amphibians, reptiles, arthropods, mollusks, and plant and animal diseases (Atkinson 1989; Towns, Atkinson & Daugherty 2006).

Once established, invasive species can cause many problems for humans by degrading natural communities, over running forests and damaging agricultural species with pests and diseases (Lockwood & McKinney 2001). Invasive aquatic species can impact local commerce by inhibiting boating along rivers, and cause local electricity emergencies by clogging the operation of hydroelectric dams, particularly in countries such as New Zealand that rely on hydroelectric power (Alonso et al., 2001).

Bioinvasions (i.e. the successful establishment and spread of species outside their native range) are increasingly frequent, and can have detrimental consequences, including the erosion of biodiversity

and the disruption of invaded ecosystem function (Simberloff, 2000). They can also cause public health risks, and damages to agriculture and fisheries.

Island ecosystems have evolved independently of many pests or predators being colonised primarily by plants and animals that can float on the sea or are carried by the wind. Introduced invasive species like many plants, dogs, cats, mice, rats, ants etc can devastate island endemic species (Solem, 1983; Cowie, 1996a). The Tongan Megapode bird and Coconut crab may be examples of species that have been negatively impacted by over-exploitation and invasive species.

Suggestions:

1. What is the species richness and diversity of invasive species that live around your area?
2. Choose one invader and study the population and the significance of its presence.
3. What impact do invasive species have on island ecology?
4. What impact do invasive species have on island economy?
5. How do invasive species get to your islands?
6. Can you restore endemic species populations and how would you do that?

References:

Alonso, A., Dallmeier, F., Granek, E., Raven, P. **2001**. Biodiversity: Connecting with the Tapestry of Life. Smithsonian Institution/Monitoring and Assessment of Biodiversity Program and President's Committee of Advisors on Science and Technology, Washington, DC.

Atkinson, I. A. E. **1989.** Introduced animals and extinctions. *Conservation for the Twenty-First Century* (eds D. Western & M.C. Pearl), pp. 54–75. Oxford University Press, New York.

Cowie, R. H., **1996a**. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. *Evolution* **49**: 1191–12 02.

Lockwood, J.L., McKinney, M.L. **2001**. *Biotic Homogenization*. Kluwer Academic Publishers, New York.

Ricklefs, R.E., Schluter, D. **1993.** *Species Diversity in Ecological Communities: Historical and Geographical Perspectives*. University of Chicago Press, Chicago.

Simberloff, D. **2000**. Extinction-proneness of island species—causes and management implications. *Raffles Bulletin of Zoology* **48**, 1–9.

Solem, A. **1983**. Endodontoid Land Snails from Pacific Islands (Mollusca: Pulmonata: Sigmurethra). Part II. Families Punctidae and Charopidae, Zoogeography. Field Museum of Natural History, Chicago.

Terborgh, J., Lopez, L., Nunez, V.P., Rao, M., Shahabuddin, G., Orihuela, G., Riveros, M., Ascanio, R., Adler, G.H., Lambert, T.D., Balbas, L. **2001.** Ecological meltdown in predator-free forest fragments. *Science*, **294:** 1923–1926.

Towns, D.R., Atkinson, I.A.E., Daugherty, C.H. **2006.** Have the harmful effects of introduced rats on islands been exaggerated? *Biological Invasions*, **8**, 863–891.

Scientific Report Format

Scientific research is performed by testing hypotheses. Usually, this is done using replication. Replication is when you test the same thing more than once and preferably no fewer than three times. The results of these experiments or observations should be written up in a scientific report.

Science reports require; a Title, Abstract, Introduction, Materials and Methods, Results, Discussion and Reference sections.

Title: Less than ten words and should reflect the content of the report and should use key words.

Abstract; The abstract should be 100-200 words long and be a concise summary of the purpose of the report, the data presented and the major conclusions.

Introduction: Defines the subject of the report, the scientific purpose or objective for the research being performed and gives the reader sufficient background to understanding the rest of the report.

Why was the study undertaken? May be derived from observations or from literature.

What knowledge exists about this subject? Answer this from a literature review showing the historical development of an idea including the confirmations, conflicts and gaps in existing knowledge.

What is the purpose of this study? What is your hypothesis or hypotheses and experimental design.

Materials and Methods: All materials and methods used in the experiments should be reported in this section. Generally, this section attempts to answer the following questions;

What materials were used?
How were they used?
Where and when was the work done?

Results: summarise the data without discussing their implications. Data should be organised into tables, figures, photographs and so on. All figures and tables should have descriptive titles and should include legends to explain symbols, abbreviations etc.

All columns and rows in tables and axes in figures should be labeled.

Discussion: Synthesise the information from your introduction and the results sections. Were you able to reject your null hypothesis? How can the experiment be improved? What future research could be carried out?

Reference List: You should have included numerous references in your text and each reference cited needs to be listed in alphabetical and chronological order in the Reference List. references should be listed in the style that has been used in this document.

General Comments

1. Scientific names should be italicised or underlined.

2. Every sentence should have a subject and a verb

3. Avoid using the first person “I” or “we”. Instead of saying ‘We weighed the frogs and put them in a glass jar’ write, ’the frogs were weighed and put in a glass jar’.

4. Be consistent in the use of tense throughout a paragraph.

5. After finishing a report read it through several times and edit your work.