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The Australian Museum Lord Howe Island Expedition 2017—Balls Pyramid Survey for Phasmids

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Abstract. The Australian Museum in partnership with Melbourne Zoo, the New South Wales Office of Environment and Heritage (NSW OEH), the Lord Howe Island (LHI) Board and the LHI Museum along with a team of experienced climbers, landed on the remote and almost inaccessible Balls Pyramid on 21 March 2017. The expedition objectives were to *(a)* determine the extent to which the critically endangered Lord Howe Island Phasmid (LHIP) *(Dryococelus australis)* existed beyond the restricted area in which it had previously been observed; *(b)* bring back four individuals for the Melbourne Zoo breeding program; and *(c)* sample other invertebrate taxa. A team of eleven climbers and support staff spent eight days on Balls Pyramid establishing suitable infrastructure for exploring and sampling LHI phasmid habitat from base to summit, and during daylight and after dark when conditions become particularly perilous. Survey results clearly established that the LHI phasmid is distributed widely across Balls Pyramid with 17 individuals being observed on *Melaleuca howeana* at more than five different elevations from below Gannett Green right up to Cheval Ridge just below the summit. Although less than expected, possibly because of recent drought conditions on Balls Pyramid, the 17 sightings meant that a single female LHI phasmid was able to be returned to Melbourne Zoo to bolster the breeding program.

Keywords. *Dryococelus australis*; Lord Howe Island; beetles; conservation; extinction; climbers.

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Figure 1. Base Camp at sunset. A light from one of the climbers can be seen up on the Pyramid (photo Tom Bannigan).

The Lord Howe Island Phasmid (LHIP) *(Dryococelus australis)* is one of the world's rarest and most critically endangered invertebrates. It was believed to have become extinct in the 1920s following the unintentional introduction of Black Rats *(Rattus rattus)* onto Lord Howe Island (LHI). However, in the 1960s climbers (Priddell & Carlile, 2003) found evidence of their existence on Balls Pyramid whilst scaling the summit. In 2001 a visiting group of entomologists discovered a number of phasmids on *Melaleuca* bushes on a ledge below Gannett Green. The LHIP wasn't extinct after all, this was later conclusively confirmed by a DNA analysis that compared Museum specimens from LHI with live phasmids, of Balls Pyramid origin, from the Melbourne Zoo breeding program (Mikheyev *et al.,* 2017). In 2003 a team from the LHI Board and the NSW OEH visited the bushes to collect two pairs of live phasmids for a breeding program at the Melbourne Zoo which would go on to establish breeding populations around the world.

In 2016 as part of its 190th anniversary celebration, the Australian Museum began its planning for an expedition to LHI. Through conversations with the LHI Board, NSW OEH and the Melbourne Zoo it became clear that Balls Pyramid needed to be included in the expedition.

It was agreed that a special approach to the Balls Pyramid expedition was required due to the nature of the collecting environment. The logistics and safety aspects of surveying Balls Pyramid were extreme, due to its remoteness (it is 23 km from LHI and 602 km from Port Macquarie), inaccessibility (it can only be accessed by swimming from a moored boat) and its steep terrain (it is 551 m high, only 300 m wide and 1.1 km long) which requires traditional rock climbing skills to ascend.

The LHIP population on Balls Pyramid had never been assessed beyond the small stand of *Melaleuca* where it was identified in 2001 (Priddell *et al*., 2003; Carlile *et al*., 2009). There was a clear need to determine whether the population was restricted to the small collection of bushes where the insects were first identified (Priddell *et al*., 2003; Carlile *et al*., 2009). The area was under threat by Morning Glory *(Ipomoea cairica)* and required weeding on a regular basis (NSW Government, 2017). Since rediscovery in 2001, three nocturnal surveys took place in 2002, 2003 and 2005. The 2005 survey recorded the greatest number with 35 adults and five nymphs observed (Priddell *et al*., 2003). Four individuals were collected for the captive breeding programme in 2003 (Priddell *et al*., 2003; Carlile *et al*., 2009). There had been no *in situ* studies since 2005.

A more systematic survey of the Pyramids terrain was required as previous efforts had been restricted to Gannett Green at around 130 m above sea level leading to speculation that perhaps this may be the only habitable phasmid area (Carlile *et al*., 2009; NSW Government, 2017). The steep terrain and lack of technical climbing experience and equipment preventing surveys from exploring areas beyond that.

Evidence of LHIP exoskeletons and a deceased adult specimen were found along the south east ridge by climbers from the 1964 and 1969 climbing parties (Priddell & Carlile, 2003). Their presence that high was attributed to carriage by birds (Carlile *et al*., 2009). Photos showing many other stands of *Melaleuca* were judged as likely being unfavourable to phasmid habitat due to lack of moisture and soil (Carlile *et al*., 2009).

In 2014 two climbers on an unsanctioned ascent photographed three live phasmids on the Cheval ridge at 480 m above sea level (asl).

This finding combined with some impetus in the rat eradication programme, and a planned Australian Museum expedition to LHI in 2017 renewed interest in landing a survey team on Balls Pyramid. It was recognized that a

Figure 2. Preparing for the Balls Pyramid expedition, packing team: Keith Bell, David Gray and Brian Mattick.

team of experienced climbers was essential to perform an adequate survey of the LHIP population at areas other than the original site.

Goals of the expedition:

- Survey the SE ridge of Balls Pyramid from sea level to summit during the day and night time to establish the range and habitat of the phasmid and to observe in situ behaviour.
- Collect up to four live specimens, and 30 eggs depending on numbers found, to strengthen the Melbourne Zoo's breeding program and to support overall efforts to conserve the phasmid particularly with the opportunity provided by the impending rat eradication on LHI.
- Collect LHIP frass to study gut biome.
- Collect other invertebrates of the Balls Pyramid terrestrial insect and mollusc fauna to add to the existing 36 specimens in the Australian Museum database (see Table 2).

Methods

A permit was obtained from the OEH for six climbers to ascend Balls Pyramid via the SE Ridge. In addition, permits were obtained for four people in Base Camp at any one time. The expedition party consisted of the six climbers: Zane and Paul Priebbenow, Keith Bell, Brian Mattick, Vanesa Wills and David Gray; and four Base Camp members: Paul Flemons, Hank Bower, Frank Köhler and Tom Bannigan with Kate Pearce from Melbourne Zoo exchanging with Frank Köhler mid-way through the expedition. The landing was scheduled for March 2017 to try and minimize disruption to nesting seabirds, especially sooty terns.

The heavy dependency on weather conditions for landing, working on and departing from Balls Pyramid meant that the expedition required significant flexibility in planning and logistics and robust contingency plans. As a result, plans were made for carrying on 10 days worth of supplies for the 10 inhabitants. It was estimated that the survey work on Balls Pyramid would take six to eight days to complete however the team believed they would still achieve significant outcomes with as little as four days. Fortunately, the weather conditions were favourable and the expedition was able to land as planned on 21 March 2018. Weather conditions were such that the team were able to stay on for eight days before the impending tail end of Tropical Cyclone Debbie forced them off.

Climbers were provided with training in phasmid sampling techniques and general collecting as well as identification of nymphs, juveniles, male and female phasmids, eggs and frass. Base Camp staff included Kate Pearce from Melbourne Zoo who is a scientist with direct experience in phasmid husbandry. Equipment and food was carefully packed into barrels under strict biosecurity guidelines prior to transport.

Due to the requirement for nocturnal surveys, fixed ropes were placed by climbers along the SE ridge for 720 m of the 950 m long climbing section of the route. Supplementary ropes were fixed to enable access off the many gendarmes to nearby *Melaleuca* bushes.

Figure 3. The expedition team on the LHI dock preparing to pack the boat for Balls Pyramid.

Ropes were also fixed in place in proximity to the 2001 phasmid bush site so that the Base Camp crew could safely access this area in the dark to conduct field surveys. On another occasion climbers assisted the Base Camp crew to ascend safely to Gannet Green for a survey during the day.

All fixed ropes were removed at the completion of the survey.

Climbers worked as three teams of two, the pairings being Zane Priebbenow and Paul Priebbenow, Vanessa Wills and Dave Gray and Keith Bell and Brian Mattick. Communication between climbers and with Base Camp was via UHF radio.

The Base Camp team consisted of representatives of the Australian Museum (Paul Flemons and Frank Köhler), the LHI Board (Hank Bower), Melbourne Zoo (Kate Pearce) and a photojournalist (Tom Bannigan).

Climbers bivvied in small rock shelters, high on Balls Pyramid to conduct localized surveys, or timed descent to occur in the dark to try and optimize adult phasmid sightings. Bushes were surveyed during the day and during the night to identify frass, eggs, nymphs, and adult phasmids.

Botanical surveys were conducted near areas of phasmid sightings to identify plants other than *Melaleuca howeana* that may be a food source. Soil and leaf litter was collected into calico bags from many sites and returned to Base Camp for assessment.

Phasmid sampling

Objectives

The two primary aims of the phasmid survey and collection expedition were to *(i)* estimate the current size and extent of the phasmid population on Balls Pyramid and *(ii)* collect new individuals to supplement the genetic diversity of the captive insurance population. An additional aim was to collect samples to allow comparison of the gut biome of phasmids on Balls Pyramid with those in the captive population to aid in future management decisions.

Permitted collection numbers

The permit allowed for the collection of up to four individuals but not more than 10% of the observed population. For example, if 10–19 animals were observed, one individual could be collected. If between 20–29 animals were observed, two individuals could be collected. If between 30–39 individuals were observed, three individuals could be collected. And if 40 or more individuals were observed, then four individuals could be collected. In addition, a total of up to 30 eggs could be collected, regardless of the size of the observed phasmid population.

Figure 4. The Base Camp Team (left to right): Hank Bower, Tom Bannigan, Frank Köhler, and Paul Flemons.

Figure 5. Hank Bower helping the climbing team recognize phasmid frass.

Figure 6. The expedition team (left to right, back row): Tom Bannigan, Zane Priebbenow, Paul Flemons, Dave Gray, Hank Bower, Keith Bell. Front row: Anthony McVean, Brian Mattick, Paul Priebbenow, Vanessa Wills, Kate Pearce, and Rhiannon Stephens

Survey and collection strategy

Climbing and Base Camp teams visited as many locations with patches of *Melaleuca howeana* (tea tree) and *Cyperus lucidus* (sedge) as was safe and feasible in the time-frame, and in accord with the conditions detailed in the LHI Board Research Permit (LHIB 01/17) and OEH Scientific License (SL100487).

Each location was examined during daylight hours for evidence of frass and/or live phasmids and visited again at night where evidence was found (see details below). Even when frass was not observed during the day, the largest patches of vegetation were surveyed at night where possible. Surveys of new sites were to be continued even if the collection limit was to be reached. If phasmid populations were located at multiple sites, it was preferable that individuals were collected from at least two, but up to four locations. The exact collection plan was dependant on the route taken and the possibility of re-visiting locations. The preferred composition of the collected group was two adult males and two adult females. However, three females and a male were preferred to one female and three males. Adults were preferred to juveniles, but juveniles were to be collected if no adults were available. As a guide, if more than 20 individuals were located at one site, one male and one female adult were to be collected. If between 10–19 individuals were observed at a location, one adult female or male were to be collected, depending on the sex of already collected individuals (e.g. if two females had already been collected, then a male was to be collected).

Similarly, eggs were preferable if collected from at least two sites, up to the permitted total of 30 eggs.

Searches for eggs were focussed on locations where adults or frass had been located.

Survey and collection method

Live animals and frass

Targeted vegetation patches were searched first during the day for signs of frass beneath bushes, and for juveniles that may have been alone or aggregated in the vegetation. The GPS location and altitude were recorded for all inspected sites, along with a brief description of habitat. If any phasmids were observed, the number of adults and juveniles was recorded at that site.

Collection of live animals

Live animals were picked up gently (preferably with disposable latex gloves) and placed, separately, in one of the provided holding tubes. The following was then done:

- Several cuttings of the plant on which the animals were found was placed into the holding tube
- An additional plant sample (about 20 cm in length) was placed in a labelled zip-lock bag
- The holding tube was labelled with the time, date and location
- The details of the situation in which the animal was found was recorded
- Photo and GPS fix of the location where the animal was found was recorded
- The holding tube was placed inside a bag and kept in a shaded location so as not to overheat
- Animal was taken to Base Camp for transport to LHI
- Fresh frass was collected from inside holding tubes each day (see below) and stored
- Secateurs were sterilized with ethanol before and after cutting vegetation

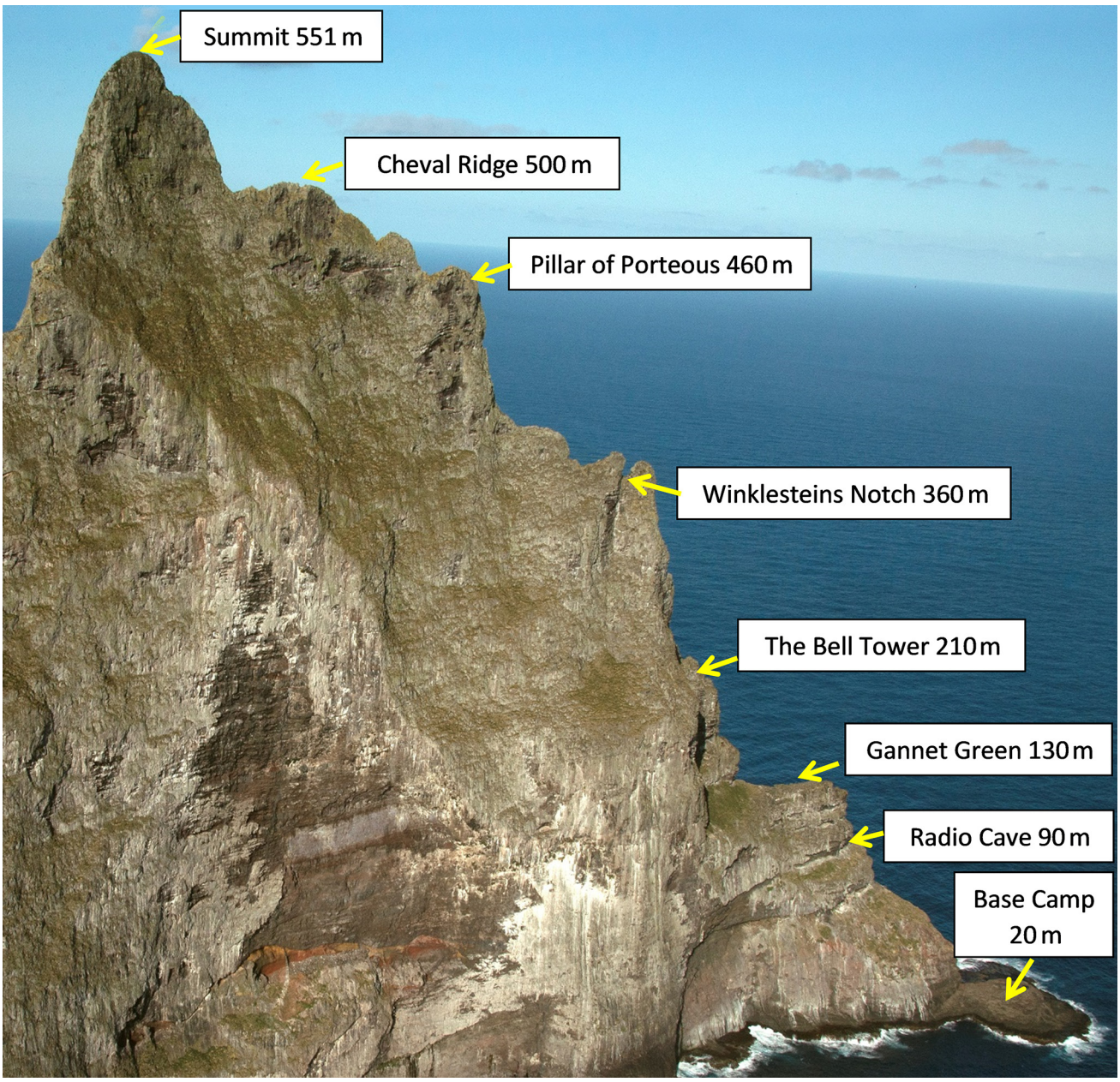

Figure 7. South East Ridge nomenclature (photo Ian Hutton).

Hand search and sieve substrate for eggs

At sites where frass or phasmids were observed, leaf litter and/or soil from under vegetation were sieved and the remaining material examined for eggs. The following procedure was then applied:

- Eggs picked up with provided sterile plastic spoon and placed in provided collection tubes
- Tube inverted until the eggs were buried in the sand /vermiculite in the supplied tubes
- Tubes labelled with the date and location
- Eggs that were either black in appearance or empty were not collected
- Photos and GPS fixes of the locations where the animals were found was recorded
- Tubes with eggs were kept in shaded location at all times
- Tubes with eggs were taken to Base Camp

Collection of frass

Fresh frass was collected from the holding tube once a day and placed in a container using disposal latex gloves. Frass for each individual on each day was placed in a separate container. Each sample was labelled with the date and individual's identity. Samples were kept as cold as possible, and frozen on return to Lord Howe Island.

Where old frass was found at visited locations, a sample of up to 25 pellets was collected and placed in provided tubes. A new tube was used for each different site. These tubes were labelled with the date and collection location. Samples were to be kept as cold as possible, and frozen at the first opportunity. Soil samples were searched through for frass back on LHI and placed in tubes/vials.

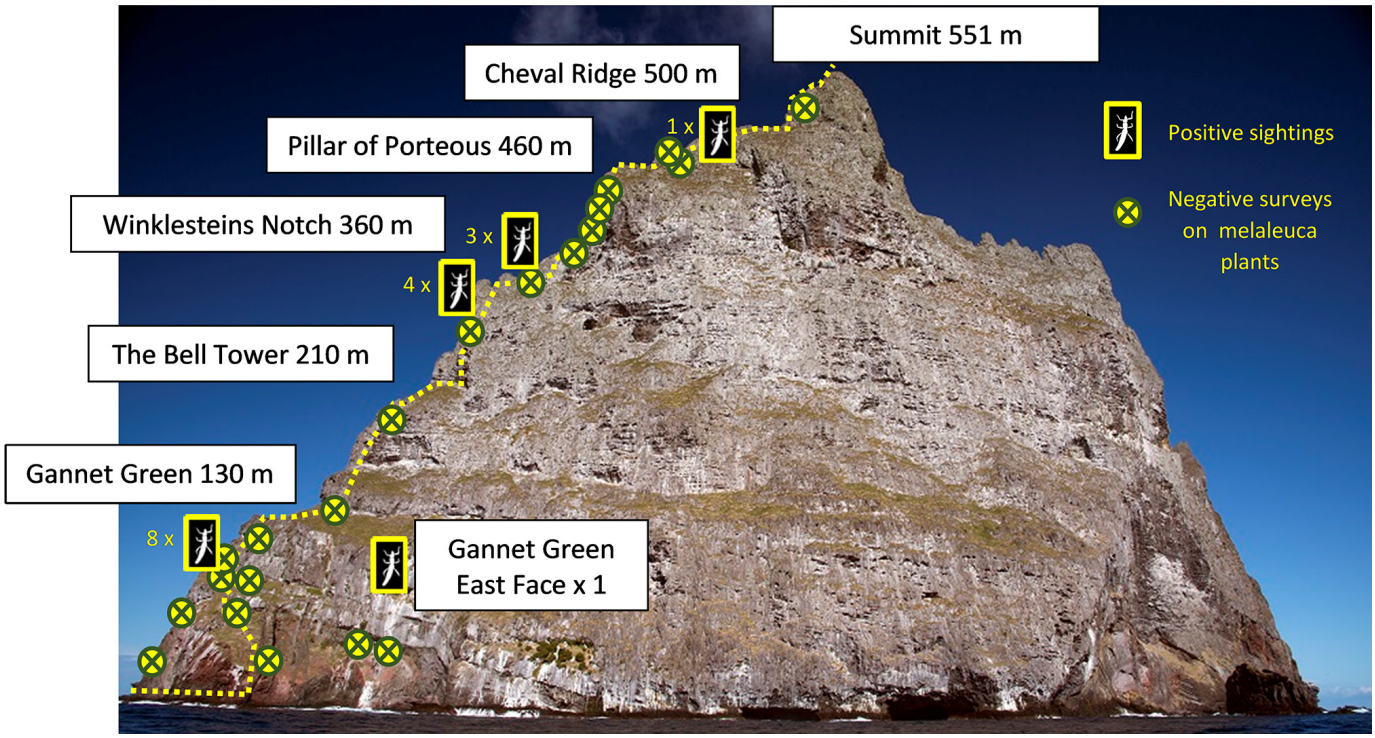

Figure 8. Balls Pyramid showing survey locations of positive phasmid sightings and negative results (photo Ian Hutton).

Invertebrates sampling

General sampling for other invertebrates was designed to be carried out in conjunction with the search for phasmids, with the understanding that such sampling would be subject to climbers capacity to do so within the constraints imposed by the extremely high risk sampling environment.

Collection methods

Hand collecting

Hand collecting consisted of accessing areas of vegetation, leaf litter and soil and carefully exploring these habitats for any arthropods, molluscs or annelids. Molluscs and annelids were put into dry glass/plastic vials, whether alive or dead. Other arthropods were put into vials with alcohol.

- Each vial was labelled and notes added regarding specimens in terms of location (GPS and altitude) and habitat.
- In-situ photos were taken where possible.
- Vials were transferred to storage boxes and then barrels for transport.

Vegetation sampling

Handfuls of vegetation are to be pulled up without scattering the plants and placed into plastic bags with some soil from the roots and sealed.

In such a relatively sparsely vegetated environment it was important not to over collect. Collecting was distributed so as not to exhaust any particular habitat's vegetation.

- Each bag was labelled and notes made regarding location (GPS and altitude) and habitat.
- In-situ photos were taken where possible.
- Bags were transferred to barrels for transport.
- Soil samples were processed either at Base Camp or back on LHI

Results

A team of 10 landed in favourable conditions on the rock platform at the base of the SE ridge on 21 March 2017 and set up Base Camp on this rock platform at 20 m asl. Climbing and survey activity continued daily over the next eight days and seven nights until successful extraction on 29 March 2017. On 27 March 2017 personnel were exchanged (Frank Köhler off and Kate Pearce coming on).

The summer months preceding the expedition had been unusually dry and hot with only 27.7% of average summer rainfall (89.6 ml) recorded on neighbouring LHI during December, January and February. The expedition experienced many hot days (max 28°C) and mild temperatures at night. Strong winds and rain squalls occurred on 24 and 25 March but surveys continued. The remnants of Tropical Cyclone Debbie that created major flooding on the mainland hit 48 hours after extraction.

Figure 7 provides a nomenclature to refer to the topographic features and helps locate surveyed areas as a useful adjunct to GPS coordinates. Bivy camps were made in Radio-Cave (90 m asl), Gannet Green (130 m asl), base of Winklesteins pinnacle (280 m asl), mid Winklesteins pinnacle (320 m asl) atop the Pillar of Porteus (420 m asl) and at the base of the summit spire (500 m asl). Climbers could usually comfortably survey areas of 60 × 5 m after fixing additional ropes close to these areas.

It became increasingly apparent during the ascent that frass and eggs would be difficult to find as the majority of the *Melaleuca* were in very steep terrain with vertical drops below most bushes. Soil was collected into calico bags when it had gathered below bushes and returned to Base Camp for inspection, usually within 12 hours of acquisition.

The site of the *M. howeana* bushes where phasmids were found in 2001 does have relatively flat ground below it. This area was surveyed by expedition members on four occasions during the day and three occasions at night. No frass, eggs or grazing signs or phasmids could be identified.

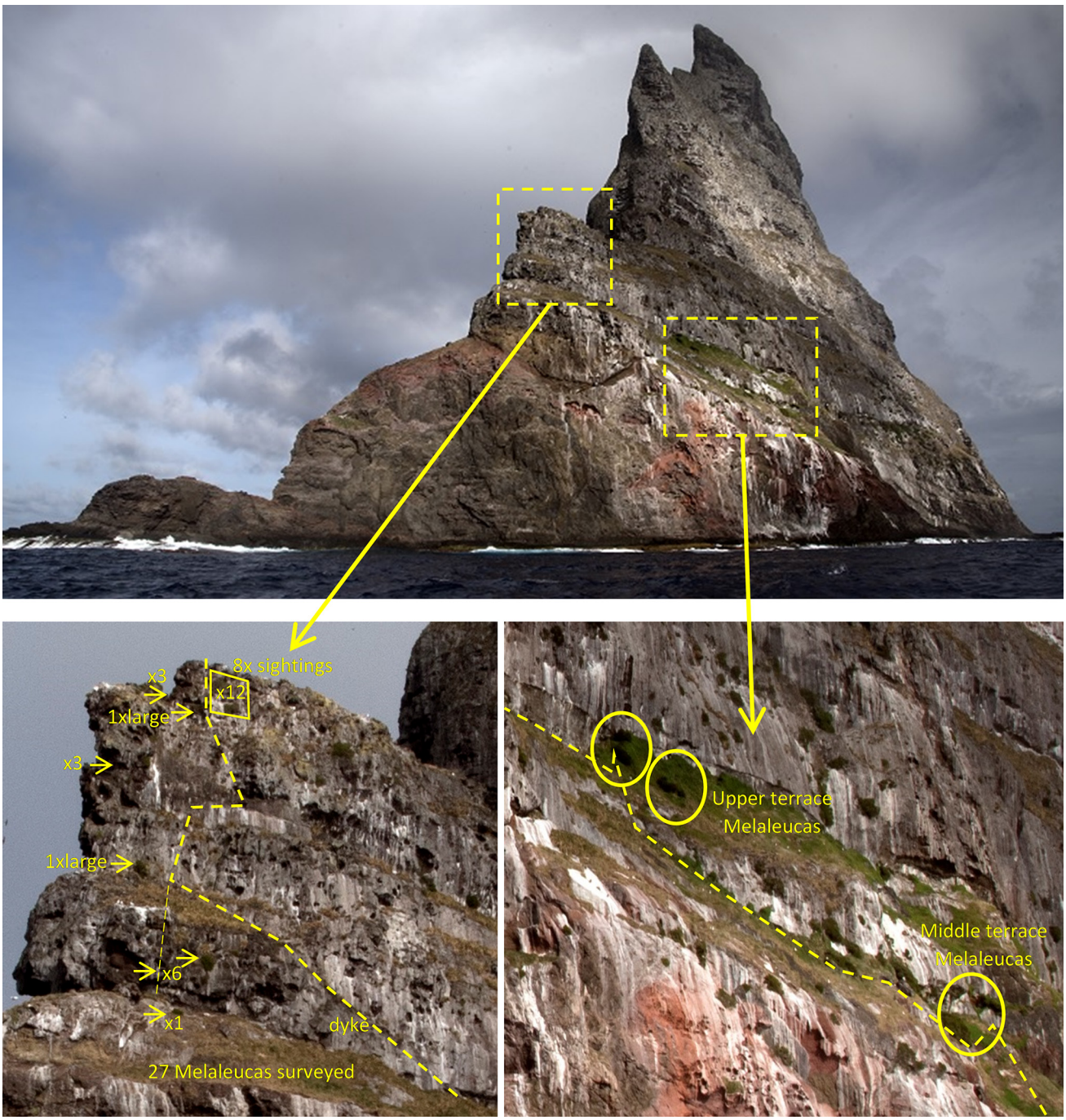

Figure 9. Detail in the vicinity of Gannett Green showing locations of searches and where phasmids were located.

One partially decomposed exoskeleton was found downhill from this bush.

Other larger bushes with soil deposits or flat earth below them such as at the base of terraces below Gannet Green and on Gannet Green seemed dry and dusty. *Melaleuca* were found along the SE ridge from 40 m asl right through to 20 m below the summit at 530 m asl. Over 150 bushes were surveyed at night, most on at least 2 occasions. Many bushes were small and stunted, growing out of cracks on vertical rock faces. Larger clusters were found atop the Pillar of Porteus near an overhang, and on the north and south sides of Winklesteins notch. Other promising bushes, especially above the mid Winklesteins bivy ledge were visible, but it was not possible to survey these in the timeframe.

A potential deposit of frass was seen in a damp crack behind a small 0.2 × 0.3 m *Melaleuca* on the cliff between Radio Cave and Gannett Green on 22 March 2017. This led to that area being surveyed that night with detection of an adult male phasmid, the first sighting of the trip. This section of cliff was the most extensively surveyed over a 10 × 70 m area and led to eight sightings in total (five male, two female, one indeterminate?). There were 30 *Melaleuca* bushes in this grid on this cliff face, at all levels, however the phasmid sightings were confined to the bushes within 10 m of the Gannet green terrace.

At a slightly higher level, and 150 m to the east one further phasmid was seen on a cluster of three large bushes on the single occasion this area was surveyed.

The phasmids were most commonly observed on the outer foliage and continued to feed even in white torch light unless the foliage was disturbed in which case they moved deeper into the bush or onto bare rock behind the bush. However, on two occasions they were observed moving across bare rock.

Table 1. Phasmid specimen count showing localities, altitudes, dates, and totals (see Figs 7–9 for location of sites on Balls Pyramid).

		date in March 2017									
Balls Pyramid localities	altitude	21	22	23	24	25	26	27	28	29	totals
Cheval Ridge	500	—	—	—	—	—	1	—	—	—	1
Winklesteins South Steeple	360	—	—	—	—	1	—	2	—	—	3
Winklesteins North Steeple	360	—	—	—	—	2	—	2	—	—	4
Below Gannet Green SE Ridge	120	—	1	—	—	1	2	1	3	—	8
Below Gannet Green East face	110	—	—	—	—	—	—	—	1	—	1
Total											

They were not observed on any other vegetation, despite climbers also seeking and collecting other specimens from these areas.

The areas of nightly survey and positive phasmid sightings are shown in Table 1. Populations seem to be clustered just below Gannet Green, as detailed above, near the Cheval Ridge, and at Winklesteins Notch.

Near the Cheval Ridge, only one male phasmid was seen on this occasion, as it crossed bare rock, but it was close to where three live phasmids were photographed in 2014.

At Winklesteins notch bushes grew relatively lushly on the north and south sides of a 1 m wide ridge line against vertical rock steps. Two phasmids were seen here during a nocturnal descent from the summit leading to a further visit two days later, on the second last night of the survey. A nymph and three other phasmids were sighted. One was thought to be definitely female but was on a bush out of reach of the rope. As the number of sightings had reached 10 at this stage, it was decided to collect two phasmids as it was difficult to determine sex while juggling a single PVC tube, on a rope while avoiding bird strike. Inspection early the next morning revealed the two collected phasmids to be a juvenile male and an adult male. They were videoed as they were released at their respective collection location. Over a few minutes they made their way to the back of a bush and disappeared into rock cracks. The PVC tube in which they had been kept overnight was returned to Base Camp with a small amount of frass.

By this stage the climbers were removing all fixed ropes in preparation for departure. It was hoped that an opportunity to collect phasmids below Gannet Green would present itself on the final night, due to reliable sightings at this level, and ropes were left in place to there.

On the final night, Zane and Paul bivvied on Gannet Green and descended via abseil over previously unsurveyed bushes that looked promising to the east of the previous sightings. Vanessa and Dave set up parallel ropes to cover as wide an area as possible at the site of previous sightings. The Base Camp crew returned to the original phasmid bush. Keith and Brian assessed bushes at the same level but 200 m to the east, almost 100 m directly under where Zane and Paul were surveying. Zane and Paul located a male phasmid 200 m east of the ridge line just below Gannet Green. The site was surveyed three hours later with no sightings. The first rope Vanessa ascended and descended, usually a reliable provider of sightings, revealed no phasmids. Ascending 5 m to the east on the second rope a male phasmid was found. Discussion ensued as to whether it should be collected as it could be the last phasmid seen. It was decided to collect it, but 2 m higher a female was seen, and she was also placed

Figure 10. Vanessa the phasmid, named after Vanessa Wills, the climber who found her. (Photo: Tom Bannigan)

Figure 11. "Vanessa" held by keeper Kate Pearce from Melbourne Zoo. (Photo: Tom Bannigan)

into the PVC tube. A third phasmid was seen another few metres higher, but determined to be male, and was left in situ. Dave returned to this area at 03h00 in the hope that sightings would increase to 20 and that the two phasmids could be kept, however no further phasmids were seen. The two phasmids were kept overnight together, but the male phasmid was returned in the morning to the bush where he was taken. He travelled over bare rock and eventually went into a crack near the trunk of a *Melaleuca*.

All nocturnal sightings occurred between 20h00 and 21h45, although this may merely represent the majority of time surveys were conducted. However, four surveys were done later than this time including the Cheval Ridge at 22h00 to 23h30, from Radio Cave to Base Camp 22h00, and from Radio Cave to Gannet Green at 22h00 and 03h00.

Overall the climbers identified 14 adult phasmids, one juvenile phasmid and two nymphs. As sightings occurred in clusters it is possible some phasmids were recounted on different nights however 10 definite unique sightings occurred: two adult females, seven adult males and one juvenile male with the remainder undetermined.

Once collected the mature female was put in a purpose-built transport tube (a PVC cylinder measuring 33 cm long, 12 cm external diameter, with end caps that have ventilation holes and a small clear Perspex viewing window that can be covered or revealed by a piece of black recycled

Figure 12. "Vanessa" in her enclosure on LHI. (Photo: Tom Bannigan)

Figure 13. "Vanessa" held by keeper Kate Pearce at Melbourne Zoo April 2017 (Photo: Rohan Cleave).

plastic. The inside was lined with marine grade waterproof carpet for perching) with a male to ensure she was mated before leaving Balls Pyramid. The ends of the tube were taped up to ensure that the end caps did not come off and cut pieces of *Melaleuca howeana* were put in the tube for food. All frass collected in the tube was kept and later frozen for future analyses. The pair spent the night together in the Radio Cave before the male was returned to the bush that he had been found on and the female was brought down to Base Camp. The tube was placed in a pop-up mesh enclosure (350 × 350 × 570 mm = W × D × H) and kept in the shade until extraction. She was given the name "Vanessa" after the climber that found her.

Upon arrival to LHI "Vanessa" was moved into a room with one wall of fly screen covered windows allowing plenty of ventilation and access to the natural climate and light cycle of LHI with no additional climate control/lighting. For quarantine purposes this room was located well away from the captive population at the LHI Board and the LHI School. The person servicing "Vanessa" daily did not come into contact with the already established population during the six nights on LHI. The tube remained within the pop-up enclosure, one end cap was taken off the tube so that it could act as a nest box and a piece of cocoa fibre matting added for additional perching. A small dish of water (changed daily) and a container of sand was added for egg laying (checked daily). Cut pieces of *M. howeana* were changed daily. All equipment was sterilized before being used.

"Vanessa" remained active overnight and fed well. She did not lay any eggs during her time on LHI and was not found in her nesting tube each morning. Instead, wedging herself between the tube and the back of the enclosure and being gently moved back to her tube each day. Once flights were available again "Vanessa" was flown back to Melbourne in her tube with a special exemption to be carried on as hand luggage and to avoid any x-ray screenings. She arrived at Melbourne Zoo on the 4 April 2017 at 16h00. The day after her arrival at Melbourne Zoo her first egg laid in captivity was found.

Throughout her time at Melbourne Zoo "Vanessa" laid 135 eggs. Each egg was weighed and measured. Each batch of eggs was set up in a ventilated container and buried 10 cm deep in vermiculite.

"Vanessa" was found deceased the morning of 10 October 2017, having been at Melbourne Zoo for just over six months.

Other taxa

The general sampling for invertebrates was carried out by all climbers as well as Base Camp members. Table 2 details 52 specimens returned and processed at the Museum including 20 spiders (class Arachnida), 22 insects (class Insecta), 5 snails (class Gastropoda) and 5 centipedes (class Chilopoda).

Arachnida

Twenty spiders were collected through a combination of hand collecting and through samples of vegetation and soil. Two of these have been identified to species, the remainder will require further work to do so.

Gastropoda

One Australian Museum malacologist visited three sites at the base and lower slopes of Balls Pyramid while climbers, who were instructed to collect leaf litter samples and macroinvertebrates, visited sites at altitudes higher than 100 m above sea level.

One widespread species was found on Balls Pyramid, *Tornatellinops* sp., whose taxonomic status is pending closer examination, and one shell fragment of *Howearion* sp.

Figure 14. Photos, location, date and time for each phasmid sighting. *(a)* Phasmid; 22-03-2017 8:26 pm; below Gannet Green. Photo Vanessa Wills. *(b)* Phasmid; 25-03-2017 9:01 pm; South Winklesteins. *(c)* Nymph; 25-03-2017 9:06 pm; North Winklesteins. *(d)* Phasmid; 25-03-2017 9:26 pm; North Winklesteins. *(e)* Phasmid; 25-03-2017 10:45 pm; below Gannet Green. *(f)* Phasmid; 26-03-2017 10:37 pm; below Gannet Green. *(g)* Phasmid; 26-03-2017 9:01 pm; below Gannet Green. *(h)* Phasmid; 26-03-2017 11:27 pm; Cheval Ridge. Photo Brian Mattick. *(i)* Phasmid; 27-03-2017 9:09 pm; below Gannet Green. Photo Brian Mattick. *(j)* Phasmid; 27-03-2017 c. 8:00 pm; South Winklesteins. *(k)* Unphotographed male; phasmid; 27-03-2017 c. 8:00 pm; South Winklesteins. *(l)* Phasmid; 27-03-2017 7:57 pm; North Winklesteins. *(m)* Nmph; 27-03-2017 9:02 pm; South Winklesteins. *(n)* Phasmid; 28-03-2017 9:30 pm; East face below Gannet Green. Photo Paul Priebbenow. *(o)* Unphotographed male; phasmid; 28-03-2017 10:34 pm; below Gannet Green. *(p)* Phasmid; 28-03-2017 9:03 pm; below Gannet Green. *(q)* Phasmid; 28-03-2017 c. 9:00 pm; below Gannet Green.

Insecta

Order Coleoptera

Family Carabidae

Carabids are generally known as ground beetles, although many Australian species are arboreal.

Notoplatynus hilaris (Olliff, 1889). 2 specimens, Balls Pyramid, 31°45'23"S 159°15'16"E, 130 m, Gannet Green, 21–26.iii.2017.

Notoplatynus hilaris is endemic to Lord Howe where it is widespread and common. Here it is newly recorded from Balls Pyramid and Blackburn Island. Length 8–11 mm.

Family Cerambycidae

Cerambycids are longhorn beetles, usually with larvae that bore tunnels in dead or dying wood.

Rhytiphora sp. 1 new record: 1 specimen, Balls Pyramid, 31°45’S 159°15’E, unspecified locality, 21–26.iii.2017 AM Balls Pyramid exped.

Rhytiphora sp. The genus *Rhytiphora* includes several hundred species in Australia, New Guinea and the Pacific (Slipinski & Escallona, 2013) and we are currently unable to identify this species. However, it is certainly a new generic record for the Lord Howe Islands and it may represent un undescribed endemic species. Larvae inhabit a wide variety of hosts, including dead wood and the living stems of herbs (Slipinski & Escallona, 2013). Length 13 mm.

Family Scarabaeidae

This diverse family includes scarabs, dung beetles and chafers.

Cryptodus tasmannianus Westwood, 1841. 1 specimen [missing limbs], Balls Pyramid, 31°45’24”S 159°15’17”E, Pillar of Porteous, 380 m, 21–26.iii.2017 AM Balls Pyr Exped; 1 specimen, Balls Pyramid, 31°45’24”S 159°15’17”E, radio cave, 80 m, 21–26.iii.2017 AM Balls Pyr Exped.

Cryptodus tasmannianus is a common and widespread species in eastern Australia, first recorded from Lord Howe by Carne (1957). However it is unclear if it was ever collected

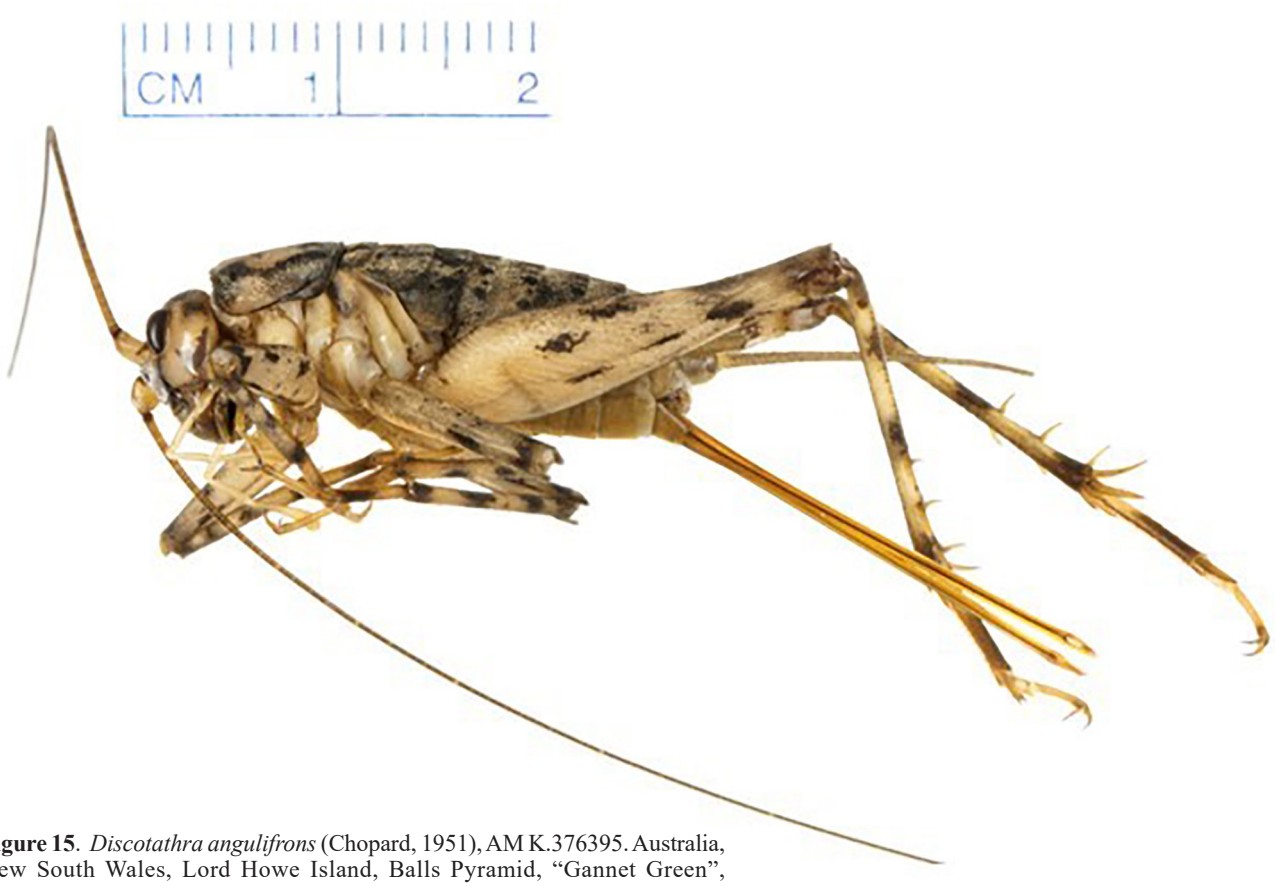

Figure 15. *Discotathra angulifrons* (Chopard, 1951), AM K.376395. Australia, New South Wales, Lord Howe Island, Balls Pyramid, "Gannet Green", 31°45'22"S 159°15'15"E, 21 Mar 2017.

on the main island. All material in the Australian Museum is from Balls Pyramid, where it is associated with sedges (Cyperus lucidus), the larva probably feeding on their roots. The presence of this mainland Australian species on only Balls Pyramid is a mystery, but it may have been eliminated by rats from the main island. Length 17–22 mm.

Family Tenebrionidae

Tenebrionids include darkling beetles and wireworms. Most species on Lord Howe are flightless.

Celibe exulans (Pascoe, 1866). 1 specimen, Balls Pyramid, 31°45'S 159°15'E, unspecified locality, 21–26.iii.2017, AM Balls Pyr Exped.

Celibe exulans is a morphologically variable flightless species, endemic to Lord Howe (Matthews, 1993). It is found throughout the lowlands and also on Blackburn Island and Balls Pyramid. The larvae of this genus inhabit soil. Length 7–17 mm.

Hydissus vulgaris (Olliff, 1889). 1 specimen, Balls Pyramid, 31°45'S 159°15'E, unspecified locality, 21–26.iii.2017, AM Balls Pyr Exped; 1 specimen, Balls Pyramid, 31°45'24"S 159°15'17"E, radio cave, 80 m, 21–26.iii.2017, AM Balls Pyr Exped; 1 specimen, Balls Pyramid, 31°45'23"S 159°15'16"E, Gannet Green, 130 m, 21–26.iii.2017, AM Balls Pyr Exped.

Hydissus vulgaris is a flightless species, endemic to Lord Howe. It is widespread in low and mid elevations, often found in rotting wood or under stones. Here we record it from Balls Pyramid for the first time. Length 8–13 mm.

Metisopus curtulus (Olliff, 1889). 3 specimens, Balls Pyramid, 31°45'24"S 159°15'17"E, radio cave, 80 m, 21–26.iii.2017, AM Balls Pyr Exped.

Metisopus curtulus is another flightless species, endemic to Lord Howe. Its distribution and habitats are similar to *H. vulgaris* and the species are often found together. This species was recorded from Balls Pyramid for the first time. Length 7–10 mm.

Order Hymenoptera

Eleven specimens of undetermined species of Hymenoptera were collected from the north east face and Pillar of Porteous on 21 March 2017. These are awaiting further taxonomic investigation.

Order Lepidoptera

No moths or butterflies were seen.

Order Orthoptera

Ten specimens of Orthoptera were collected from Gannett Green, Radio Cave, Pillar of Porteous and the original "Phasmid Bush".

Discussion

Phasmids

The most exciting finding of the survey is that LHIP are not just found on the original *Melaleuca* bush at 65 m asl, they are found in multiple locations along the surveyed area. Just below Gannet Green at 120 m, Winkelstein's Notch 360 m and Cheval Ridge 500 m. There are still other *Melaleuca* bushes in unsurveyed areas that may also support LHIP. Interestingly, the original "Phasmid Bush" was surveyed multiple times throughout the survey and none were seen. Had we carried out a survey like those that had been done in

Table2. Australian Museum invertebrate specimens previously collected from Balls Pyramid. Collectors: Nicholas Carlile, Steven J. Fellenberg, J. A. Friend, Margaret Humphrey, Tim Kingston, B. Miller, David Priddell, and Jim Smith.

reg number	class	order	family	species	coll. date	collector
KS.119014	Arachnida	(Acari) Ixodida	Argasidae	*Argas lagenoplastis*	Feb. 1969	Smith
K.487941	Insecta	Blattodea	Blaberidae	*Panesthia lata*	3/03/1969	Smith
K.487942	Insecta	Blattodea	Blaberidae	*Panesthia lata*	3/03/1969	Smith
K.188589	Insecta	Coleoptera	Carabidae	*Scopodes ovalis*	21/01/1980	Kingston
K.185346	Insecta	Coleoptera	Carabidae	*Scopodes ovalis*	24/01/1980	Kingston
K.185347	Insecta	Coleoptera	Carabidae	*Scopodes ovalis*	24/01/1980	Kingston
K.185348	Insecta	Coleoptera	Carabidae	*Scopodes ovalis*	24/01/1980	Kingston
KS.84032	Arachnida	Araneae	Desidae	*Forsterina*	21/01/1980	Kingston
KS.84022	Arachnida	Araneae	Theridiidae	*Cryptachaea veruculata*	21/01/1980	Kingston
KS.84023	Arachnida	Araneae	Thomisidae	*Stephanopis fissifrons*	21/01/1980	Kingston
KS.84031	Arachnida	Araneae	Desidae	*Forsterina*	24/01/1980	Kingston
KS.84035	Arachnida	Araneae	Linyphiidae	—	24/01/1980	Kingston
KS.84034	Arachnida	Araneae	Oonopidae	*Xestaspis* sp.	24/01/1980	Kingston
KS.84002	Arachnida	Araneae	Salticidae	—	24/01/1980	Friend
KS.84003	Arachnida	Araneae	Salticidae	—	24/01/1980	Kingston
KS.84004	Arachnida	Araneae	Salticidae	—	24/01/1980	Kingston
KS.84005	Arachnida	Araneae	Salticidae	*Ocrisiona melancholica*	24/01/1980	Kingston
KS.84006	Arachnida	Araneae	Salticidae	—	24/01/1980	Kingston
KS.85191	Arachnida	Araneae	—	—	24/01/1980	Kingston
KS.85192	Arachnida	Araneae	—	—	24/01/1980	Kingston
KS.85193	Arachnida	Araneae	—	—	24/01/1980	Kingston
KS.85194	Arachnida	Araneae	—	—	24/01/1980	Kingston
KS.85195	Arachnida	Araneae	—	—	24/01/1980	Kingston
KS.85196	Arachnida	Araneae	—	—	24/01/1980	Kingston
KS.7281	Chilopoda	Scolopendromorpha	—	—	24/01/1980	Kingston, Miller
KS.83994	Arachnida	Araneae	Gnaphosidae	*Anzacia mustecula*	6/02/2001	Humphrey, Priddell, Carlile
KS.84033	Arachnida	Araneae	Linyphiidae	—	6/02/2001	Humphrey, Priddell, Carlile
KS.84000	Arachnida	Araneae	Salticidae	—	6/02/2001	Humphrey, Priddell, Carlile
KS.84027	Arachnida	Araneae	Zodariidae	*Nostera nadgee*	6/02/2001	Humphrey, Priddell, Carlile
KS.91243	Chilopoda	Geophilomorpha	Mecistocephalidae	*Mecistocephalus* sp.	6/02/2001	Humphrey, Priddell, Carlile
KS.91294	Chilopoda	Scolopendromorpha	Scolopendridae	—	6/02/2001	Humphrey, Priddell, Carlile
KS.87109	Arachnida	Araneae	Orsolobidae	—	Feb. 1980	unknown
KS.10443	Chilopoda	Geophilomorpha	—	—	Feb. 1980	unknown
K.186487	Insecta	Phasmida	Phasmatidae	*Dryococelus australis*	13/02/2003	Fellenberg
K.186488	Insecta	Phasmida	Phasmatidae	*Dryococelus australis*	13/02/2003	Fellenberg
K.186489	Insecta	Phasmida	Phasmatidae	*Dryococelus australis*	13/02/2003	Fellenberg

Table 3. The 52 invertebrate specimens returned and processed at the Australian Museum including 20 spiders, 5 centipedes, 5 snails and 22 insects (see Figs 7–9 for location of sites on Balls Pyramid).

reg number	class	order	family	species	sites
KS.127405	Arachnida	Acarina	—	—	lower NE Face "Phasmid Bush"
KS.127406	Arachnida	Acarina	—	—	lower NE Face "Phasmid Bush"
KS.127407	Arachnida	Acarina	—	—	"Gannet Green"
KS.127408	Arachnida	Acarina	—	—	"Gannet Green"
KS.127409	Arachnida	Acarina	—	—	"Gannet Green"
KS.127403	Arachnida	Araneae	Linyphiidae	*Bathyphantes rainbowi* Roewer, 1942	"Radio Cave"
KS.127401	Arachnida	Araneae	Orsolobidae	*Hickmanolobus* sp.	lower NE Face "Phasmid Bush"
KS.127402	Arachnida	Araneae	Orsolobidae	*Hickmanolobus* sp.	"Gannet Green"
KS.127404	Arachnida	Araneae	Salticidae	*Ocrisiona melancholica* (Koch, 1879)	lower NE Face "Phasmid Bush"
KS.127423	Arachnida	Opiliones	Triaenonychidae	—	"Gannet Green"
KS.127413	Arachnida	Pseudoscorpiones	—	—	lower NE Face "Phasmid Bush"
KS.127414	Arachnida	Pseudoscorpiones	—	—	lower NE Face "Phasmid Bush"
KS.127415	Arachnida	Pseudoscorpiones	—	—	base of NE Face "Entrance"
KS.127416	Arachnida	Pseudoscorpiones	—	—	base of "Pillar of Porteous"
KS.127417	Arachnida	Pseudoscorpiones	—	—	"Gannet Green"
KS.127418	Arachnida	Pseudoscorpiones	—	—	"Gannet Green"
KS.127419	Arachnida	Pseudoscorpiones	—	—	"Gannet Green"
KS.127420	Arachnida	Pseudoscorpiones	—	—	"Gannet Green"
KS.127421	Arachnida	Pseudoscorpiones	—	—	"Gannet Green"
KS.127422	Arachnida	Pseudoscorpiones	—	—	"Gannet Green"
KS.127410	Chilopoda	Geophilomorpha	—	—	"Gannet Green"
KS.127411	Chilopoda	Geophilomorpha	—	—	base of "Pillars of Porteous"
KS.127412	Chilopoda	Lithobiomorpha	—	—	base of "Pillar of Porteous"
KS.127689	Chilopoda	Scolopendromorpha	Scolopendridae	—	"Radio Cave"
KS.127690	Chilopoda	Scolopendromorpha	Scolopendridae	—	"Gannet Green"
C.559474	Gastropoda	Achatinellidae	Tornatellinops	—	"Gannet Green"
C.559475	Gastropoda	Achatinellidae	Tornatellinops	—	base of NE Face "Entrance"
C.559476	Gastropoda	Achatinellidae	Tornatellinops	—	lower NE Face "Phasmid Bush"
C.559477	Gastropoda	Achatinellidae	Tornatellinops	—	base of "Pillar of Porteous"
C.559478	Gastropoda	Helicarionidae	Howearion	—	"Radio Cave"
—	Insecta	Coleoptera	Carabidae	*Notoplatynus hilaris* (Olliff, 1889)	"Gannet Green"
—	Insecta	Coleoptera	Carabidae	*Rhytiphora* sp.	unspecified locality
—	Insecta	Coleoptera	Scarabaeidae	*Cryptodus tasmannianus* Westwood, 1841	Pillar of Porteous
—	Insecta	Coleoptera	Scarabaeidae	*Cryptodus tasmannianus* Westwood, 1842	Radio Cave
—	Insecta	Coleoptera	Tenebrionidae	*Celibe exulans* (Pascoe, 1866)	unspecified locality
—	Insecta	Coleoptera	Tenebrionidae	*Hydissus vulgaris* (Olliff, 1889)	unspecified locality
—	Insecta	Coleoptera	Tenebrionidae	*Hydissus vulgaris* (Olliff, 1889)	Radio Cave
—	Insecta	Coleoptera	Tenebrionidae	*Hydissus vulgaris* (Olliff, 1889)	"Gannet Green"
—	Insecta	Coleoptera	Tenebrionidae	*Metisopus curtulus* (Olliff, 1889)	Radio Cave

... / continued next page

Table 3 [continued]. The 52 invertebrate specimens returned and processed at the Australian Museum including 20 spiders, 5 centipedes, 5 snails and 22 insects (see Figs 7–9 for location of sites on Balls Pyramid).

reg number	class	order	family	species	sites
K.379589	Insecta	Hymenoptera	—	indet. Hymenoptera	base of "Pillar of Porteous"
K.379599	Insecta	Hymenoptera	—	indet. Hymenoptera	base of NE Face "Entrance"
K.376394	Insecta	Orthoptera	—	*Austrosalomona zentae* Rentz, 1988	"Gannet Green"
K.376396	Insecta	Orthoptera	—	*Austrosalomona zentae* Rentz, 1988	"Gannet Green"
K.379448	Insecta	Orthoptera	—	*Austrosalomona zentae* Rentz, 1988	"Gannet Green"
K.379449	Insecta	Orthoptera	—	*Austrosalomona zentae* Rentz, 1988	"Radio Cave"
K.376395	Insecta	Orthoptera	—	*Discotathra angulifrons* (Chopard, 1951)	"Gannet Green"
K.376397	Insecta	Orthoptera	—	*Discotathra angulifrons* (Chopard, 1951)	base of "Pillar of Porteous"
K.463348	Insecta	Orthoptera	—	*Discotathra angulifrons* (Chopard, 1951)	"Radio Cave"
K.379595	Insecta	Orthoptera	—	indet. Orthoptera	"Gannet Green"
K.379447	Insecta	Orthoptera	—	unknown orthopteran	lower NE Face "Phasmid Bush"
K.377827	Insecta	Zygentoma	—	*Heterolepisma* Escherich, 1905	"Base Camp"
K.261254	Insecta	Zygentoma	—	*Heterolepisma* sp. (probable new species)	"Base Camp"

the past, we would not have had any animals to bring back to Melbourne Zoo.

The climbers observed the stick insects going into cracks in the rock when released after wandering around the rock face. It was previously thought that the phasmids huddled together in hollowed out sections of living melaleucas as observed in the *Ficus* trees on LHI by Lea (1916) or in cavities formed in accumulated plant debris (Priddell *et al.*, 2003) .

The overall number of phasmids found was lower than expected. Previous surveys found up to 34 LHIP's in and around the "Phasmid Bush" but none were found in that area this time. However, fluctuations in numbers had been noted from 2001 to 2003 and it was thought that rainfall and humidity were determinant in this population flux (Carlile *et al.*, 2009). Previous surveys had seen more females than males, however this time it was the reverse. This may indicate some seasonal variation that we do not see in captivity. LHI had experienced a very dry summer which may have seen the animals utilize the younger softer leaved bushes located on moisture seeps higher up. Observations of captive populations have shown how critical humidity is to phasmid survival (Honan 2008). The LHIP might always be found all over the Pyramid but may not always use the older bushes that are not so young, fresh and moist as others. This bush may form part of their habitat only when conditions are good.

It is of some concern that there was no sign of phasmid activity at the original *Melaleuca* bush location. There is some dispute as to whether this area had aerial spraying for morning glory (Carlile *et al.*, 2009). It is possible the morning glory has impacted habitat or the human visitation to try and control the weed has affected the population. Other unrecorded visitation to this area is also possible due to its relative accessibility. A repeat survey in a year with more rainfall would help assess whether the absence of phasmids from this area is only a temporary phenomenon.

This study has demonstrated that the phasmids do survive and live along the SE ridge and do not require large deposits of soil or leaf litter for habitat. They are adept climbers and appear to inhabit deep cracks in the day time and range some distance at night to feed on *Melaleuca howeana*.

It is unknown whether eggs are laid within the cracks or whether females deposit eggs in the open and survival is a matter of chance. Large skinks and geckos are ubiquitous but predation on adult phasmids and nymphs was not observed.

The use of thin endoscopic equipment would provide a useful adjunct to nocturnal surveys and enable visualization deep into cracks and permit collection of eggs and frass using endoscopic baskets if deposits inside rock chambers are identified.

If further cliff surveys are to be conducted collecting equipment could be refined to be more practical to a vertical environment.

Although the present survey demonstrated the population of the phasmid to be widespread along the SE ridge, overall recorded numbers were low suggesting the population on Balls Pyramid is at risk. Until such time as a viable wild population can be restored to LHI, it would be unwise to allow recreational rock climbing on Balls Pyramid. However, rock climbers do have a valuable role in collaboration with survey teams for the removal of weeds and future population surveys. All landing parties on Balls Pyramid need to maintain the highest biosecurity precautions to prevent transmission of weeds, other pathogens such as *Phytophthora* or myrtle rust, and introduction of animals such as rats or cockroaches.

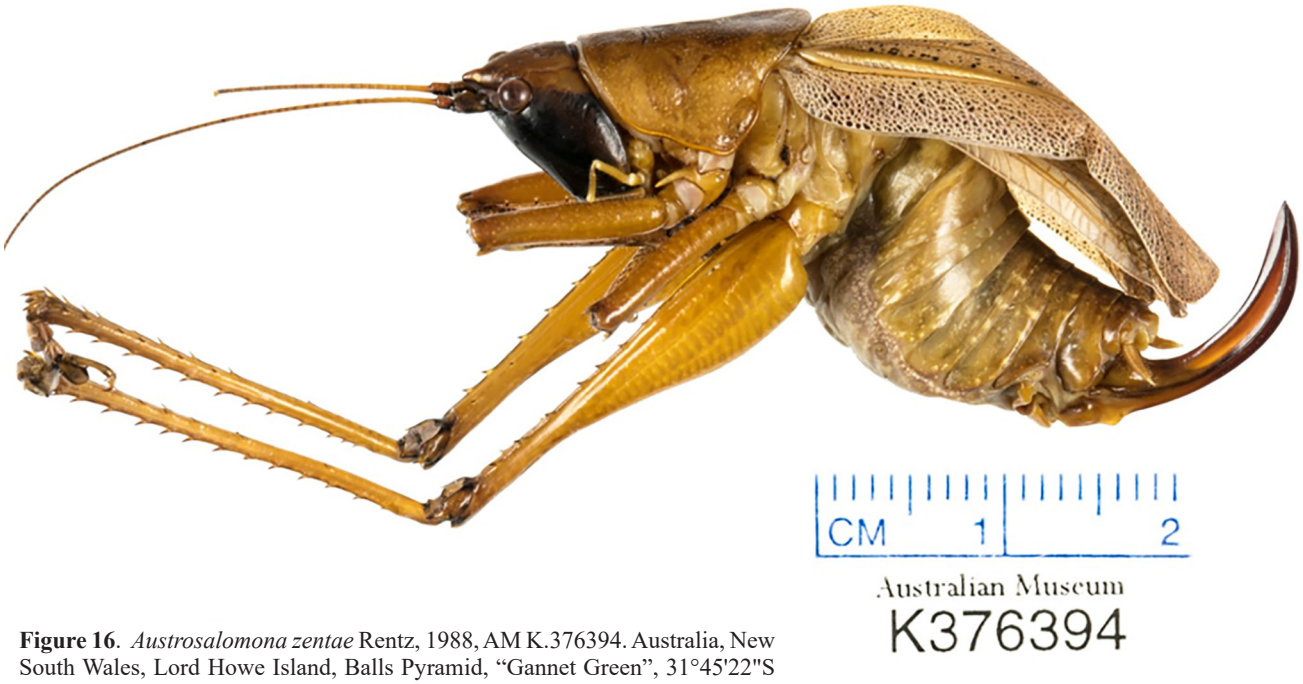

Figure 16. *Austrosalomona zentae* Rentz, 1988, AM K.376394. Australia, New South Wales, Lord Howe Island, Balls Pyramid, "Gannet Green", 31°45'22"S 159°15'15"E, 21 Mar 2017.

Other taxa

The number and diversity of other taxa collected on this trip were less than expected, likely reasons being the difficult conditions under which collecting was carried out, the focus of the work on phasmids and the extremely dry conditions leading up to the expedition.

Many of the specimens found were not recognised as named species and will require review and identification by specialists when an opportunity arises for them to be analysed.

Acknowledgments. We are particularly grateful to the generous donors of the Australian Museum Foundation for their interest and generosity which made the 2017 Expedition to LHI possible. We are greatly indebted to Hank Bower, the LHI Board and Ian Hutton (LHI Museum) for their unflagging assistance, support, encouragement and advice; Clive Wilson for his expertise in helping us land on Balls Pyramid; Nicholas Carlile for his experience and advice on matters Balls Pyramid and phasmids and the survey program; Museum colleague Jessica O'Donnell for assisting us in organising our accommodation and equipment.

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