Artificial cover objects for leiopelmatid frogs

DOC SCIENCE INTERNAL SERIES 120

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Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

DOC Science Internal Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff, or external contractors funded by DOC. It comprises progress reports and short communications that are generally peer-reviewed within DOC, but not always externally refereed. Fully refereed contract reports funded from the Conservation Services Levy (CSL) are also included.

Individual contributions to the series are first released on the departmental intranet in pdf form. Hardcopy is printed, bound, and distributed at regular intervals. Titles are listed in the DOC Science Publishing catalogue on the departmental website http://www.doc.govt.nz and electronic copies of CSL papers can be downloaded from: http://www.csl.org.nz

ISSN 1175-6519

ISBN 0-478-22421-4

In the interest of forest conservation, DOC Science Publishing supports paperless electronic publishing. When printing, recycled paper is used wherever possible.

This report was prepared for publication by DOC Science Publishing, Science & Research Unit; editing and layout by Helen O'Leary. Publication was approved by the Manager, Science & Research Unit, Science Technology and Information Services, Department of Conservation, Wellington.

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ABSTRACT

Artificial cover objects (ACOs) for monitoring *Leiopelma archeyi* and *L. hochstetteri* frogs were designed and tested in the Waikato region, New Zealand. Occupancy of 119 covers of 7 different designs was recorded between May 1998 and March 2002. From March 2001 the covers were visited monthly. In the course of 1260 cover checks, a total of 26 *L. archeyi* and 17 *L. hochstetteri* were found inside the trial ACOs. Most of the designs were used by frogs but to different extents (occupancy ranging from 0% to 21%). Analyses of these results are reported and the suitability of the designs for use in monitoring frog populations is discussed.

Keywords: Anura, leiopelmatid, Archey's frog, Hochstetter's frog, artificial cover objects, refugia, monitoring, chytrid fungus.

Wakelin, M.; Smuts-Kennedy, C.; Thurley, T.; Webster, N. 2003: Artificial cover objects for leiopelmatid frogs . *DOC Science Internal Series 120*. Department of Conservation, Wellington. 17 p.

1. Introduction

Recent dramatic declines in populations of Archey's frog (*Leiopelma archeyi*) (Bell 1999) as well as declines and extinction in frogs overseas (Crump 1992; Drost & Fellers 1996; Laurance et al. 1996; Lips 1998, 1999) have highlighted the need for monitoring frog populations in New Zealand. Regular, standardised monitoring is vital for determining population trends and alerting management agencies to any potential collapses. During the course of this study a chytrid fungus, believed to be implicated in international declines (Lips 1999), was initially suspected and eventually found in dead Archey's frogs (R. Norman, Massey University, pers. comm.; B. Waldman, Canterbury University, pers. comm.). The more aquatic Hochstetter's frog (*L. hochstetteri*) was thought to be more vulnerable to the waterborne fungus than Archey's frog (Waldman 2001), but it is Archey's frog populations that seem to be affected (Bell 1999).

Currently there is no reliable standardised monitoring method for detecting changes in populations of either Hochstetter's or Archey's frogs. The commonest method has been daytime manual searching—which can be time-consuming, damaging to the habitat and prone to observer bias (Smith & Petranka 2000). Other methods for monitoring amphibian populations are described by Heyer et al. (1994) who also considered providing artificial cover objects (ACOs) a useful method. The advantages of using ACOs include a lower time commitment, potentially larger sample sizes, reduced observer bias, and that they are non-damaging to habitat, replicable, durable, and standardised (Monti et al. 2000). ACOs of various designs have been used widely, usually on salamanders (DeGraaf & Yamasaki 1992; Bonin & Bachand 1997; Davis 1997). Comparisons of different monitoring methods have found that results can vary, as found for manual searching compared with pitfall trapping of frogs in New South Wales (Goldingay et al. 1996), and pitfall traps compared with cover boards for skinks (Sutton et al. 1999). Nocturnal searches are regarded as more successful than other methods of monitoring amphibians including ACOs (Pearman et al. 1995; Parris et al. 1999), but ACOs were better than quadrat or transect searches for salamanders, particularly after a year of 'settling in' (Monti et al. 2000). However, differential settling in of covers between areas is a potential problem (Davis 1997; Bonin & Bachand 1997). Binckley et al. (2000) found wooden ACOs better than brick, cement, plastic or dinner plates for salamanders; and that one large ACO was better than several smaller ones covering a similar area. Other important points of survey design to consider before undertaking monitoring are noted by Parris (1999).

Preliminary work in the Waikato region (conducted by CS-K) had some success with ACO designs for Archey's frog sites, but these were not suitable for Hochstetter's frog sites which are prone to flooding.

The aim of this project was to develop a standardised monitoring technique for mainland leiopelmatid frogs, identified as an objective in the Native Frog Recovery Plan (Newman 1996), by testing ACOs of various designs to see if frogs would use them. Any suitable design could then be the subject of further research into their usefulness for monitoring frog populations.

2. Methods

On the assumption that ACOs should bear some resemblance to natural objects, ecological information on the frogs was considered when designing them. Archey's and Hochstetter's frogs grow to 37 mm and 38–44 mm (snout-vent length) respectively (Bell 1982). Archey's frogs in the Coromandel area are found mostly in rocky sites under forest or on open ridges (Bell 1982). Natural daytime cover in Whareorino (one of the study sites) comprises logs 0.5–2 m long (16% of encounters), stones 10–40 cm in diameter (31%) and vegetation (52%) consisting of rice grass, hook grass, tree fern and crown fern (Thurley & Bell 1994). Densities as high as 8 frogs/m^2 have been recorded, but averaged 1.8 frogs/m^2 (Bell 1994).

Hochstetter's frogs prefer cool, shady, rocky, forest creeks and muddy seepages. During the daytime Hochstetter's frogs shelter beneath rocks (stable, moss-covered, flat rocks, generally > 15 cm in diameter), logs, vegetation and leaf litter (Bell 1982; McLennan 1985; Newman & Towns 1985). Manual daytime searching has found Hochstetter's frogs in a range of stream size and vegetation cover including pine and scrub, with the important factor being shade from overhanging vegetation (Shaw 1993). The areas recording the highest densities of Hochstetter's frogs are steep-sloped, minimally degraded, stream headwaters, with frogs found above the flood level of flood-prone streams, mostly within 25 cm of a watercourse but also up to 4 m away (McLennan 1985; Newman & Towns 1985; Green & Tessier 1990). Densities of 30 to 50 frogs per 100 m of stream have been recorded, with a maximum find rate of 18 frogs/h (Green & Tessier 1990). Another study found variable densities, with as many as 5 frogs/m^2, and a find rate of 4 frogs/h (Mclennan 1985). Variability in density and encounter rate during daytime searching could be an artefact of climate which can influence frog activity at night. The activity of Hamilton's frog (*L. hamiltoni*) is correlated with rainfall (during and preceding searching), relative humidity, light intensity and temperature (Newman 1990). Similarly, the night-time emergence of Archey's frog is correlated with relative humidity, rainfall and wetness of vegetation (Cree 1989); and in daytime searches more frogs have been found during or after rain (Thurley & Bell 1994). Perfect (1996) found a correlation between numbers of Hochstetter's frogs found and rainfall over the preceding days.

This information was considered when designing seven ACOs to test their frog usage. The designs incorporated features to test preferences for various substrates e.g. plastic versus fabric (saucers, lunchbox), black versus light (propagation tray) and rough versus smooth (lunchbox); for line of sight to the outside (propagation tray, plank); and for tapered, squeezed or open spaces (all designs). Although Archey's frog and Hochstetter's frog may have slightly different requirements it was decided to test the same designs on both species.

2.1 SITE SELECTION

Site selection was based on a known high density of frogs and relative ease of access. An existing or previously monitored population nearby was considered an advantage. Two forested ridge sites were selected at Whareorino Forest (174°48′E, 38°24′N), west of Te Kuiti for Archey's frog testing. A stream site at Waitekauri (Stream 14, Whitaker & Alspach 1999) at the base of the Coromandel Peninsula (175°46′E, 37°20′N), was selected for Hochstetter's frog testing.

2.2 ACO TRIALS

The artificial cover trial began in July 1997, when two designs were established in a known Archey's site at Whareorino. Eight Smuts sheets (Fig. 1A) and eleven Smuts saucers (Fig. 1B) were deployed, with at least a 2 m spacing between ACOs. The ACOs were spread around an area of approximately 20 × 100 m and were not checked until May 1998. The low level of frog occupancy found in these trials indicated a need to test different designs.

Five more covers were designed and deployed in February and March 2001. Clusters of these five designs were installed at 10 different sites in Whareorino and 10 sites at Stream 14 at Waitekauri. The five designs were clustered near one another (with c. 1 m spacing) to provide frogs with a direct choice, but each cluster of designs was at least 10 m from another to sample different frogs. At Waitekauri, ACOs were tied in place to prevent loss from flooding.

Checks on ACOs (cover checks) were made at monthly intervals from March 2001 until March 2002. Multiplying the number of ACOs by the number of checks gave the total number of cover checks for each type of ACO. Percentage occupancy was calculated from these data. All equipment and footware was cleaned of mud and washed with Virkon® S fungicide between sites to prevent any spread of the chytrid fungus.

2.2.1 ACO designs

The seven designs (see Fig. 1) were constructed as follows:

Smuts sheet (Fig. 1A)

One piece of corrugated transparent plastic (400 × 400 mm) was laid over the ground with a piece of black polythene (800 × 800 mm) laid over the top. Both squares of plastic were pegged down at the corners with metal pegs and orange twine crossed over the Smuts sheet at 300 mm above the ground to discourage animal trampling.

Smuts saucer (Fig. 1B)

Two plastic plant pot saucers were placed bottom-to-bottom with five, 10 mm high plastic spacers between them. The saucers were held together by a central nut and bolt passing through a 100 mm length of 20 mm PVC conduit. This pinched the centre of the saucers together to provide a tapered space for the frogs. The top saucer was covered with soil and rocks to improve the cover's ability to retain moisture. Drainage holes were drilled in both saucers. Three sizes of this design (measuring 300, 350 and 400 mm in diameter) were made.

Saucer (Fig. 1C)

Two, 35-cm-diameter, terracotta-coloured, plastic plant pot saucers (Euro 3 Plast) were nested together, and held apart at the outer edge by 25 mm spacers (sylon, white PVC angle). Eight holes (30 × 15 mm) around the edge of the bottom saucer allowed frog entry. The space between the trays tapered towards the centre where two pipes (grey PVC conduit, 20 and 25 mm in diameter) secured with galvanised pins held the trays together. Lengths of capillary matting (Aquafelt) and artificial grass provided different textures for the frogs to rest on and held moisture. Drainage holes were drilled in both saucers, enabling water to reach the matting materials. The top saucer was filled with rocks and leaf litter at the site for water retention, to improve temperature and physical stability, and to provide the impression of a 'bulky' object under which frogs could retreat.

Sandwich (Fig. 1D)

A 300 × 300 mm piece of clear, Tufclad™, corrugated plastic was placed between two equal size pieces of black (Sunboard), foam PVC plastic. Two pegs made from the foam PVC and secured with a galvanised nail held the layers firmly together. Drainage holes were drilled in all layers. At each site, a rock was used to hold the cover to the ground.

Propagation tray (Fig. 1E)

Two black propagation trays (320 × 260 mm) were nested together with a sheet of white, Marley Hippolon™ between. Spacers made of black (Sunboard), foam PVC slotted onto the central sheet holding it at an angle and keeping the seed trays apart. Eight holes (30 × 15 mm) gave entry to two tapered spaces between the two trays. The central sheet was sanded to aid traction and half was sprayed black to test whether brightness influenced frog use. The top tray had a lining sheet (of weed mat) which prevented debris falling through while allowing water in; it was filled with rocks and leaf litter at the site.

Plank (Fig. 1F)

Two, 450 × 240 mm lengths of James Hardie Frontier Weatherboard were joined, 'rusticated' surfaces together, by cattle eartags. Spacers made from black Sunboard held the boards apart creating a tapered space and entrance holes for frogs. When installing this ACO, one end was placed against an object to close it off.

Lunchbox (Fig. 1G)

A clear, plastic, 5-L food container with snap-on lid had 8 entrance holes (30 × 15 mm) drilled around the bottom edge. Extra drainage holes were drilled in the sides, top and bottom. Inside, 250 × 150 mm lengths of white, capillary matting; black weed mat; white polypropylene Coreflute; and black weed mat, were placed to provide loose cover for frogs of contrasting textures. The transparent sides of the container were sprayed black to reduce light entering. A rock was placed on top to prevent disturbance.

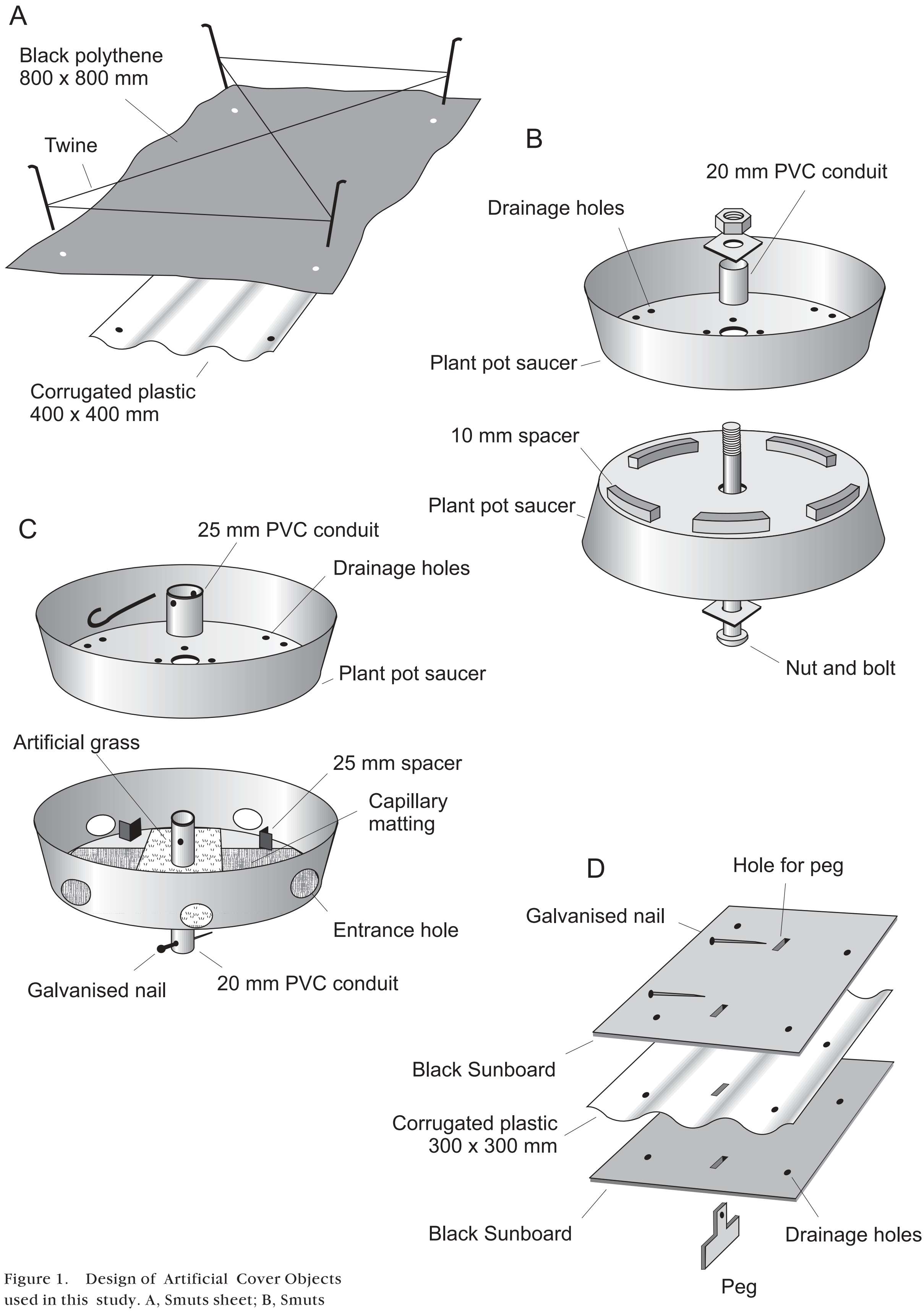
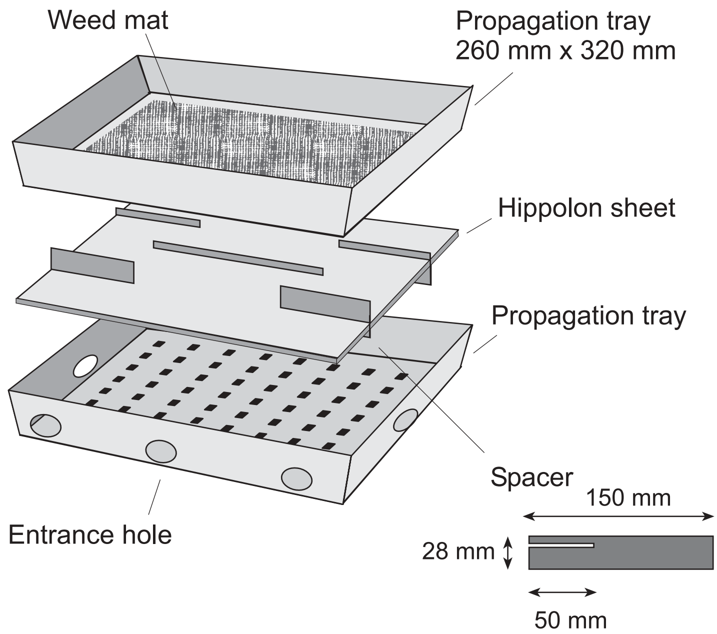
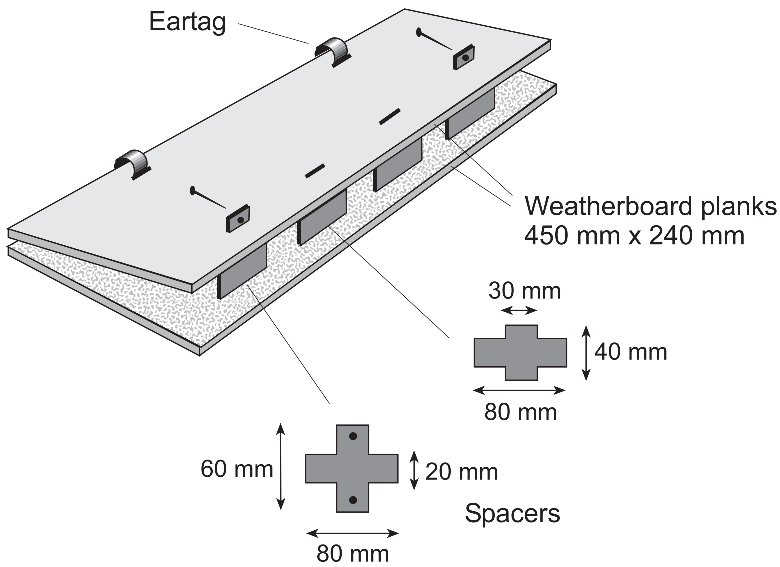


Figure 1. Design of Artificial Cover Objects used in this study. A, Smuts sheet; B, Smuts saucer; C, saucer; D, sandwich; E, propagation tray; F, plank; G, lunchbox.

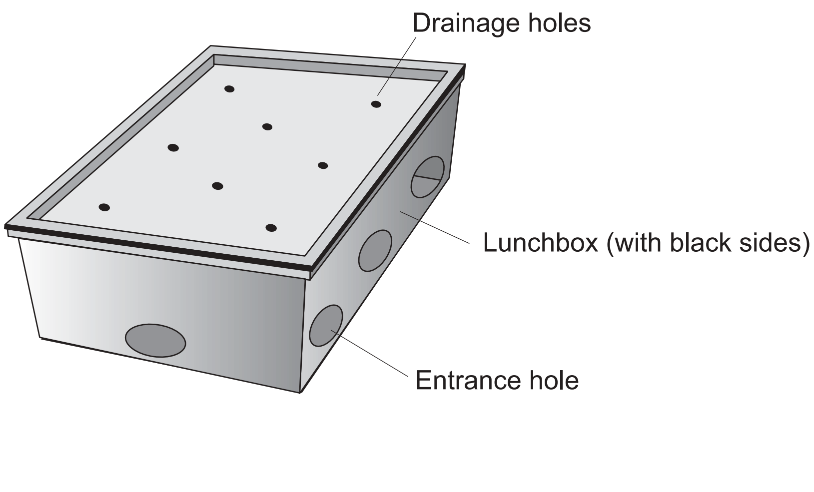
E


Weed mat
Propagation tray
260 mm x 320 mm
Hippolon sheet
Propagation tray
Spacer
150 mm
28 mm
50 mm
Entrance hole

F


Eartag
Weatherboard planks
450 mm x 240 mm
30 mm
40 mm
80 mm
60 mm
20 mm
Spacers
80 mm

G


Drainage holes
Lunchbox (with black sides)
Entrance hole

3. Results

At Whareorino Forest, the Smuts saucer was the ACO most frequently occupied by Archey's frogs (Table 1). The ACO most frequently occupied by Hochstetter's frogs was the plank (Table 1). At Waitekauri, only one Hochstetter's frog was found in an ACO, which was of the sandwich design (Table 2).

In addition to the frogs found inside ACOs at Whareorino, one Archey's frog was found under a stone on the lid of one of the sandwich ACOs, and another under a stone on top of a plank. One Hochstetter's frog was found under a log on top of a lunch box. At Waitekauri, one Hochstetter's frog was found under a propagation tray.

TABLE 1. NUMBER OF ARCHEY'S (AF) AND HOCHSTETTER'S (HF) FROGS FOUND INSIDE ACOS IN WHAREORINO FOREST, MAY 1998–MARCH 2002.

ACO TYPE	NO. OF ACOS	NO. OF CHECKS	TOTAL CHECKS	NO. OF AF FOUND	NO. OF HF FOUND	TOTAL OCCUPANCY	PERCENTAGE OCCUPANCY
Smuts sheet	11	14	154	3	0	3	1.9
Smuts saucer	8	14	112	19	5	24	21.4
Saucer*	10	11	110	0	0	0	0.0
Lunchbox*	10	11	110	1	0	1	0.9
Sandwich*	10	11	110	0	0	0	0.0
Propagation tray*	10	11	110	2	2	4	3.6
Plank*	10	11	110	1	9	10	9.1
Total	69	83	816	26	16	42	5.1

* These designs were monitored from March 2001–March 2002.

TABLE 2. NUMBER OF HOCHSTETTER'S FROGS FOUND INSIDE ACOS AT WAITEKAURI, MARCH 2001–MARCH 2002.

ACO TYPE	NO. OF ACOS	NO. OF CHECKS	TOTAL CHECKS	NO. FROGS FOUND	PERCENTAGE OCCUPANCY
Saucer	10	9 (3*)	84	0	0.0
Lunchbox	10	9	90	0	0.0
Sandwich	10	9	90	1	1.1
Propagation tray	10	9	90	0	0.0
Plank	10	9	90	0	0.0
Total	50	45	444	1	0.2

* One of the saucer covers was buried beneath a landslip for at least 6 months.

There was multiple occupancy of Smuts saucers on four occasions. On one occasion, an Archey's and a Hochstetter's frog were found together in one Smuts saucer; on two occasions, two Archey's frogs were found together; and on one occasion two Hochstetter's frogs were found together in Smuts saucers.

On six occasions at Whareorino, a Hochstetter's frog was found in the same plank cover, located approximately 5 m above a stream. Based on size and coloration, it was possibly the same frog each time, suggesting there may be some site fidelity. At another plank cover in Whareorino, a Hochstetter's frog was also found on three occasions and it appeared to be the same individual each time.

4. Discussion

The total number of frogs found using the ACOs was small, making comparisons between the success of different designs difficult. The Smuts saucer recorded the highest percentage occupancy, which may be due to a number of possible factors. The much longer settling in or weathering period that this type of ACO had in our trials (in comparison to the later five designs) may have influenced its attractiveness to frogs. The Whareorino site where both Smuts saucers and the Smuts sheets were placed, may also have had a higher density of frogs than the sites where the other five designs were deployed. Finally, the design of the Smuts saucers may have been more attractive to frogs as it contained only a small tapered gap that seemed to retain moisture.

The Smuts sheet did not appear to be as attractive to frogs. The corrugated plastic lying near ground level often created a dry space beneath—which would be less attractive to frogs than a moist area. Lifting the sheet for checking caused little disturbance to any frogs hiding below.

The propagation tray was equally popular with Archey's and Hochstetter's fogs at Whareorino. This may be have been due to the soil and rocks that were placed on top to enhance moisture retention. To check propagation trays, a limited amount of disturbance was necessary as the top tray had to be removed to look inside.

At Whareorino, the plank design was more frequently occupied by Hochstetter's than Archey's frogs. The plank's moisture-retaining properties may have made this design more attractive to the semi-aquatic Hochstetter's frog, which has a higher environmental moisture requirement than the more terrestrial Archey's frog. Checking the planks disturbed the resident frogs because the boards needed to be raised and searched with a torch.

The lunchbox, saucer and sandwich designs were the least effective ACOs in this trial. The lunchbox was intended to provide a loose 'lasagne' of layers for the frogs to squeeze between—but the layers stuck together when damp, and the open space created did not appear to suit frogs. Lunchboxes could be checked with relative ease by removing the lid and looking under the layers.

The new saucer design was not as successful as the prototype Smuts saucer. The artificial grass and capillary matting (which was the major difference between the two designs) may have acted as frog deterrents in the new saucers. In both saucer designs, the attachments pinning the middle together to create a tapered space caused considerable difficulty when checking the covers. The Smuts saucers could usually be checked without being pulled apart by simply looking into the gap. However, the new saucer had to have its top removed to check for frogs inside. This involved removing the middle pin, resulting in considerable disturbance to any resident frogs.

In the sandwich design, the gaps between the layers were perhaps too large, influencing temperature and moisture retention within the covers. However, due to the large gap size, these ACOs could be easily checked by lifting them up and looking down the corrugations.

Some useful information can be drawn from this study. Variations such as black and white, rough and smooth, plastic and fabric, and line of sight to outside, did not appear to influence frog occupation of an ACO. The critical factors in a design appear to be creating a solid space that a frog could squeeze into (tapering for different frog sizes) and which maintains suitable moisture and temperature conditions. The ideal ACO design for frogs must be easy to make, install and inspect, and provide a standardised tool (e.g. demonstrate uniform weathering and have standardised installation). Further designs with these factors are feasible, for example using Tufa (a light pumice cement that is mouldable, stone-like, solid and stable). The addition of see-through plastic sheets may enable resident frogs to be seen with less disturbance.

At Waitekauri it is possible that the stream used for the ACO trial was not the most suitable site. There appeared to be low numbers of frogs present, as only two frogs were ever seen in the stream during the trial and a survey of the top 100 m of the stream found no frogs. The top of the catchment was planted with pine trees, which may have added to the stream's tendency to flood, and sections of the stream were quite unstable (some ACOs were partly or completely buried after floods).

None of the ACOs at Waitekauri stayed in place during the trial. When the stream was in flood, ACOS were buffeted around and would have been washed away if they hadn't been tied down. The ACOs had to be regularly relocated to the edges of the stream to prevent this. Often, there were fewer than 50 ACOs to inspect due to flood disruptions. The movement of ACOs provided no settling in time. However, rocks and logs in the stream were moved around just as frequently. The instability of the stream may explain why so few frogs were found in it. Hochstetter's frogs used ACOs at the Whareorino site, suggesting they could be monitored using ACOs placed above a stream's flood level.

The only Hochstetter's frog found inside an ACO at Waitekauri was discovered in the sandwich design. This cover was sitting on some rocks in the middle of the stream with water flowing beneath it. Another Hochstetter's frog at Waitekauri was found under a propagation tray. Frogs may use these ACOs like rocks or logs (i.e. rest beneath them on natural substrates, rather than resting inside them as shelters). If this is the case, the frogs' use of a natural on-site substrate, rather than the experimental ACO floor, destroys the ACO's advantages of repeatability and reduced observer bias.

The disruption of ACOs by flooding at the Waitekauri site lowered the overall frog encounter rate. Also, the placement of covers could not always take advantage of the most likely frog habitat. Using the best designs in the best sites might result in encounter rates in the range of 2–17% for Archey's frogs and similar rates for Hochstetter's frogs (Table 1). Other ACOs have recorded 144% encounter rates when used with salamanders (Binkley et al. 2000). More comparable encounter rates of < 30% were reported by Bonin & Bachand (1997).

This may seem a small return for the effort involved in construction, deployment and checking, but ACOs should be considered against other methods and their impacts. Manual daytime searches have found Hochstetter's frogs at densities of 5 frogs/m^2 and a rate of 4 frogs/h (McLennan 1985), with rates of 15–18 frogs/h also reported (Green & Tessier 1990). Manual night-time searches at Whareorino have found Archey's frogs at a mean density of 0.28/m^2 and at a mean rate of 19 frogs/h (T. Thurley & N. Webster, pers. comm.). One hundred of our trial ACOs would take about an hour to check, making some of the designs tested in this study as successful as manual daytime searching—without the latter's risk of habitat damage and observer bias.

4.1 MONITORING

There are many problems associated with using ACOs. They need to be standardised, but can weather at different rates (Monti et al. 2000). Their presence may artificially boost population numbers by increasing available habitat. Social interactions may also affect occupancy of ACOs, e.g. if territorial individuals take up permanent residence or prevent the use of ACOs by other frogs (Monti et al. 2000). Hochstetter's frogs may clump socially (McLennan 1985), and show site tenacity and slow recolonisation (Green & Tessier 1990). Such behaviour could create uneven and unpredictable use of ACOs, making any population estimates derived from ACO monitoring unreliable.

Before results from monitoring with ACOs can be regarded as meaningful, they need to be validated against known frog population densities, in the absence of ACOs.

5. Recommendations

Further ACO trials should be undertaken, comparing their use as a monitoring tool against other methods, e.g. night-time searching versus use of one of the current ACO designs (possibly the Smuts saucer, with modifications for ease of checking). The favoured ACO for Hochstetter's frogs (plank) should be trialed in a more suitable stream in the Hunua ranges (southwest of Auckland) to allow for its comparison as a monitoring tool with daytime searches of natural cover.

6. Acknowledgements

This research was funded by DOC (investigation number 3374). Thanks to Chris Edkins (Science & Research Unit) for assistance with the figures.

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