THE UNIVERSITY OF QUEENSLAND
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Effectiveness of rodent-proof cables in resisting damage caused by black rats *Rattus rattus*

A report to Prysmian Group

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Executive summary

This paper reports the results of a scientific experiment evaluating the effectiveness of four fibre optic telecommunication cables, supplied by Prysmian Group, in resisting damage caused by the black rat, *Rattus rattus*. This species is the major rodent pest in Australia and is known to cause extensive damage to cable installations worldwide.

A typical fibre optic cable consists of five fibre optic bundles around a Glass Reinforced Plastic (GRP) inner core, surrounded by a thick inner plastic layer and an outer plastic layer. The rodent-proofing of such cables are based on the addition of a protective layer between the inner and outer plastic layers. The protective layer consists of a rodent repellent or a resistant material, such as glass. This study tested four such cables (Samples '1' to '4'). Some cables had more than one inner or outer plastic layer, or even an outer plastic sheath.

A total of 32 black rats weighing 220-265g were live-trapped and individually housed in experimental cages. This cage was extended to a test chamber in which the rat had to gnaw through a 180mm length of cable to reach a food reward. After an acclimatisation period of three days, 8 rats were randomly assigned for testing one of the four cables. Gnawing on the cable was scored each morning for seven consecutive days, using a scoring system to measure the extent of damage into the cable.

There was a significant ($p < 0.007$) statistical difference between Sample '3' and the other cables, with Sample '3' incurring the least damage caused by rats. The damage to Sample '3' was limited to the protective layer. Rats damaged the fibre optic bundles in all the other samples. We therefore recommend that Sample '3' is used for rodent-roof installations.

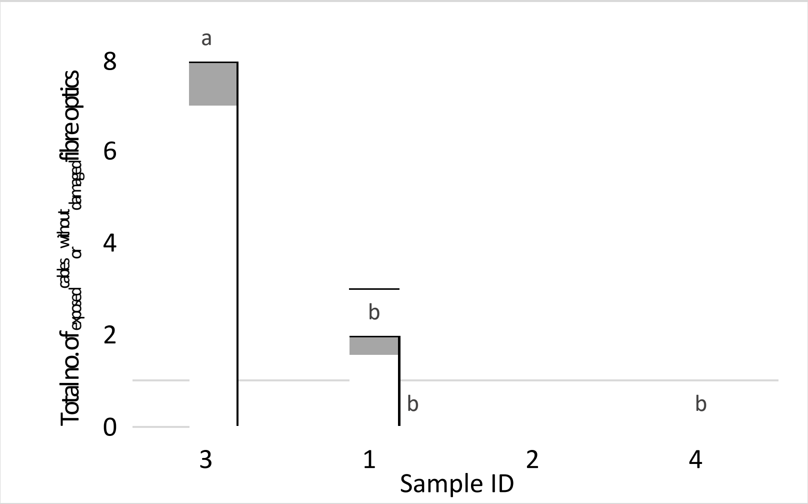

Figure A (also Figure 7). Total number of cables without fibre optics exposed or damaged by rats during the trial, in descending order. Columns that have different letters are significantly different as determined by Fishers exact test (two-tailed). Eight cables were tested for each sample.

A ranking system in the order of decreasing effectiveness in resisting rat damage ('a' and 'b'), shown in Figure A, may also be used to select cables for relative effectiveness in resisting rodent damage. Columns that have different letters are significantly different, and these can be used to "rank" cables: cables ranked 'a' are more effective than those ranked 'b'.

The test results did not provide any statistical support for selecting cables within ranks. For example, within rank 'b', it is not known if sample '1' was statistically more effective than sample '2', or if sample '2' was statistically more effective than sample '4'. Testing with a larger sample size (approx. 30 rats) will be required to identify significant differences between the cables within this rank. Results from these further tests will allow informed decisions in selecting between samples '1', '2' and '4'.

Sample '3' is a structurally strong, thick and stiff cable with a distinct protective layer, ideal for installation in areas with the highest risk of rats damaging cables, but may be not cost-effective in other situations. If the proposed test with a larger sample size of rats is conducted, Prysmian Group will be able to use the results to determine which of samples '1', '2' and '4' would the more cost-effective cable to use in areas with a moderate risk of rats damaging cables.

Introduction

The front incisors of rodents grow continuously, and gnawing is a natural behaviour of these species to maintain the sharpness and length of their incisors. Optic fibre cables are known to be attractive to rodents as an object for gnawing, and this behaviour can cause extensive damage to cable system installations.

Protection against gnawing by rodents is therefore required to minimize and prevent damage to fibre optic cables caused by rodents. Typical protection includes shielding with layers of solid spiral glass rods, longitudinal glass rovings and raw fibreglass woven mattings.

Effective protection against rodent gnawing will extend the life of a fibre cable installation, reduce maintenance costs and decrease associated operational downtime from repairing damaged cables.

This study aims to determine the effectiveness of four fibre optic cables, provided by Prysmian Group, in resisting damage caused by black rats (*Rattus rattus*). The data will be used to evaluate (1) the resistance of the cables to rodents; and (2) the failure of the rodents to gnaw through to the communications fibres.

Materials and methods

Animals and housing

A total of 32 rats weighing between 220 and 265g were used for the study. Of these, 8 rats were randomly assigned for testing one type of cable (i.e., 8 rats per cable x 4 cable). The animals were live-trapped from agricultural facilities (e.g. piggery, dairy, etc.) on the University of Queensland's Gatton campus and housed individually in wire mesh cages, in a weather-protected building on the campus.

The wire mesh cage opens to a test chamber that is constructed with a 90 mm diameter stormwater PVC pipe extending 100 mm from the cage and sealed with a standard push-on PVC cap. This test chamber is removable from the cage and the opening of the cage (to the chamber) sealed to prevent experimental animals from escaping. A barrier is constructed at a distance of 25 mm from the cage into the test chamber. This barrier consists of an approximately 180mm length of cable inserted horizontally across the pipe and two metal plates (thickness > 1 mm) affixed above and below the cable such that a small gap (approx. 5 mm) exists between the cable and adjacent metal plate. The 5 mm gap is too small for the rat to get through. Figures 1, 2 and 3 illustrate this setup.

Shading was provided to encourage the rats to explore the test chamber, by covering one-half of the cage close to the test chamber with shade cloth (Figures 1 and 3). The other end of the test chamber was also sealed with a PVC cap to darken the chamber.

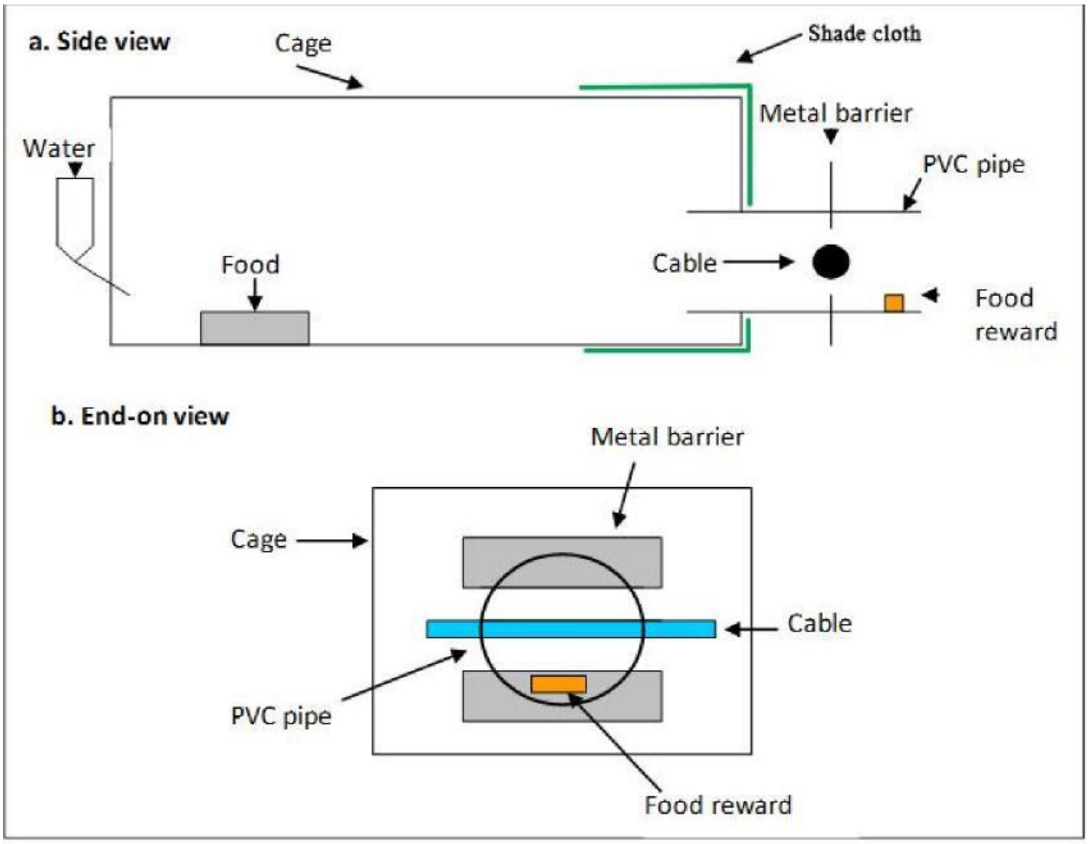

Figure 1. Side (a) and front (b) views of the experimental set up for testing the effectiveness of rodent proof cables. Adapted from Peter Elsworth.

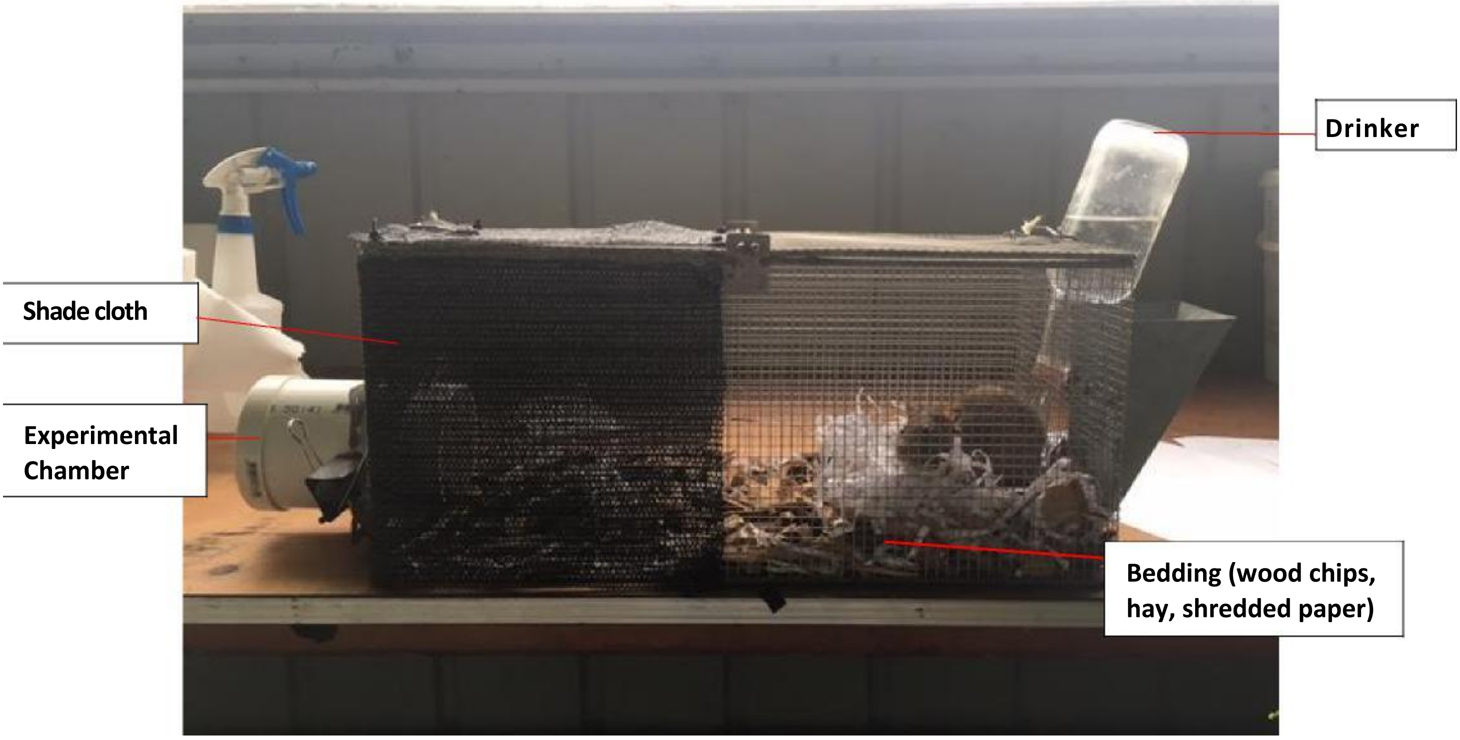

Figure 2. Side view of cage with attached experimental chamber.

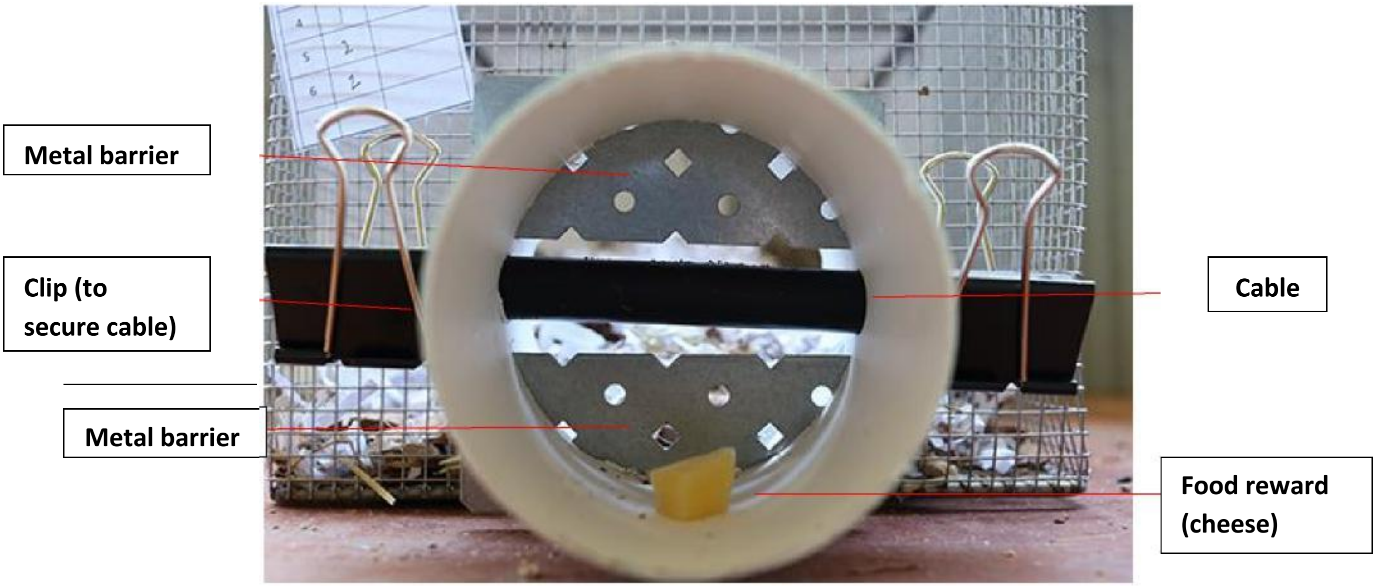

Figure 3. Front view of experimental chamber.

Food reward in the form of cheese was placed on that far end of the chamber, away from the rat, so that the rat would have to gnaw through the cable to reach the reward

(Figure 3). This is known as the 'cable reward method' (Parker 1993; Parker et al. 1993). The attractiveness of the cheese was maintained by replenishing it daily. Food and water was available *ad lib* to the rats throughout the trials (Figure 3). Normal food rations (laboratory rodent pellets) and water were provided available *ad lib* throughout the duration of the trial. Cages were maintained in ambient temperatures and daily light/dark conditions normally experienced by these wild-caught rats. Bedding was provided in the form of wood chips, hay and shredded paper so the rats' feet were not directly exposed to the mesh at the bottom of the cage. These materials were also a form of refuge.

The experiment consisted of two phases as follows:

(1)Acclimatisation period: Immediately after introduction, rats were acclimatised to the conditions of the pens over a period of three days without any experimental measurements. Diet intake was measured daily to provide a baseline of the feeding behaviour of the experimental animals before commencement of the test. Weights were taken on the final day of the acclimatisation period to ensure rats were at least 220g.

(2) *Test period:* On Day 1, the test chamber extension was attached to the cage (Figures 4 and 5). This included a 180mm length of test cable, placed horizontally between the two metal plates in the PVC pipe, and secured at the ends (Figures 3 and 5) The food reward was placed on the other side of the barrier, away from the rodent.

Figure 4. Cage without extension chamber and opening (unsealed). A PVC cap is used to seal the opening during the acclimatisation phase.

Figure 5. Cage with extension chamber attached, during the experimental phase. A PVC cap is used to minimize light entering the chamber, and a food reward (cheese) placed at this end.

Damage to the cable caused by the rat was scored daily in the morning for seven consecutive days. An ordinal scale was used for the scoring because damage is shown simply in order of increasing magnitude given there is no standard of measurement of differences. This ordinal scale is listed in Table 1.

Table 1. Ordinal scale for scoring damage to a fibre optic cable caused by an adult black rat.

0 – none
1 – gnawing on the outer plastic sheath and layer
2 – exposure of the protective material
3 – exposure of the inner plastic layer
4 – exposure of the fibre optic bundles
5 – damage to the fibre optic bundles

At the end of the test period, the cable was removed and a final score assigned. If the cable reached the maximum score of '5' within the test period, the remains of the cable were removed from the cage as no further damage assessment is required.

Description of cables

Each cable comprised of five fibre optic bundles around an inner core, surrounded by at least one thick plastic layer. Some cables had a protective layer (see Figure 6).

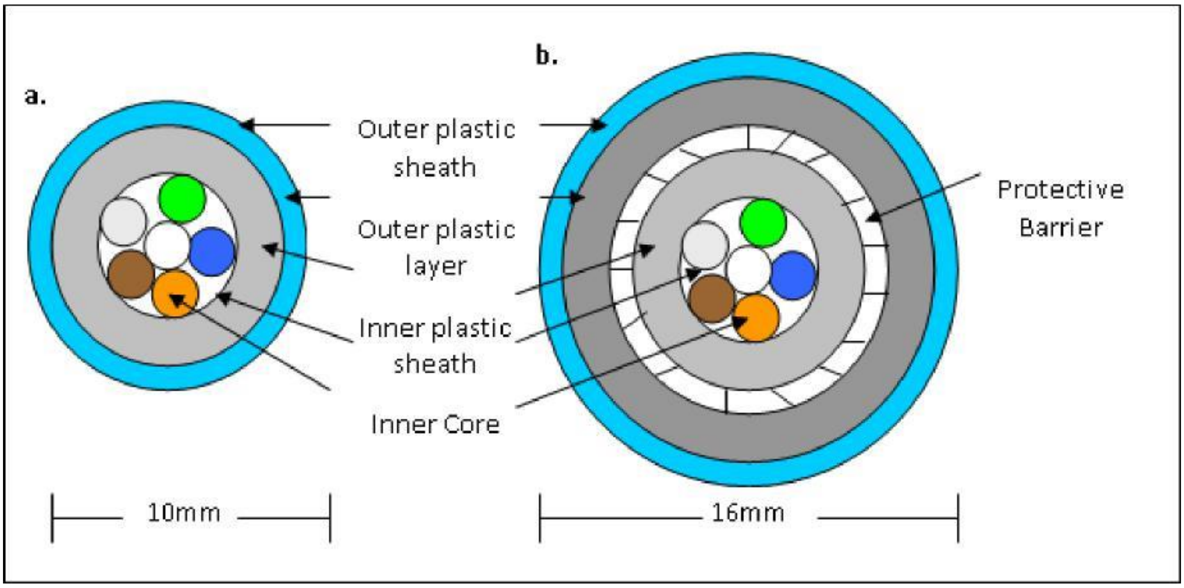

Figure 6. Schematic cross-section of examples of a cable without rodent proofing, (**a**), and a test cable with a rodent-proof protective layer (**b**).

Analysis

The primary aim of the trial was to compare the incidence of penetration to the inner core in the cables. The first four damage scores were combined to indicate success of rodent-proofing (no damage, gnawing of outer plastic sheath and layer, exposure of protective material and exposure of the inner plastic layer). The last two damage scores were combined to indicate failure of rodent-proofing. The data were then analysed using Fishers exact test (two-tailed), as 2 x 2 contingency tables.

Results

Sample ‘3’ was effective in resisting damage caused by rats. All eight rats penetrated to only the protective layer.

Rodent-proofing was completely ineffective for Samples ‘2’ and ‘4’, with all eight rats gnawing to the fibre optic core. These cables differed significantly to Sample ‘3’ ($p<0.005$; Figure 7).

Rodent-proofing was generally not effective for Sample ‘1’. Damage to the fibre optic core was caused by six rats. The remaining two rats damaged only the protective and inner plastic layers. Sample ‘1’ was significantly different to Sample ‘3’ ($p=0.007$). The p value of the Fisher’s exact test (two-tailed) between each pair of samples is listed in Table 2.

Table 2. Probability values of Fishers exact test (two-tailed) between each pair of samples (‘1’ to ‘4’). Probability values less than 0.05 are statistically significant (*).

Sample ID	1	2	3	4
1		0.467	0.007*	0.467
2	0.467		<0.005*	1.000
3	0.007*	<0.005*		<0.005*
4	0.467	1.000	<0.005*	

Sample No.	Sample Description
1	Prysmian SM@RTCORE Duct Cable
2	Prysmian LOR@T Fibreglass Woven Tape Rat Resistant Cable
3	Prysmian NOR@T GRP Armoured Rat Proof Cable
4	Competitor A Glass Yarn Armoured Rat Resistant Cable

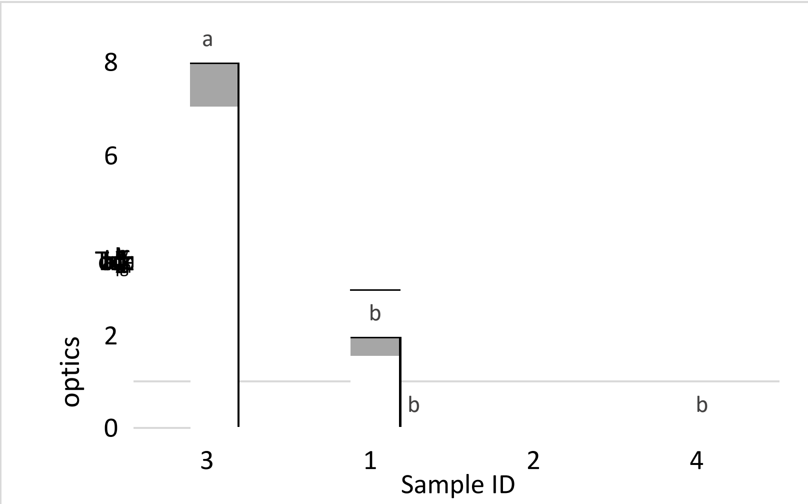

Figure 7. Total number of cables without fibre optics exposed or damaged by rats during the trial, in descending order. Columns that have different letters are significantly different as determined by Fishers exact test (two-tailed).

Damage occurred a lot earlier during the test to cable '2' than the other cables (Figure 8). Four rats penetrated to the fibre optic bundles within 24 hours, and all eight rats penetrated to the fibre optic bundles by Day 4. For Sample '4', all rats exposed or damaged the fibre optic bundle by Day 6.

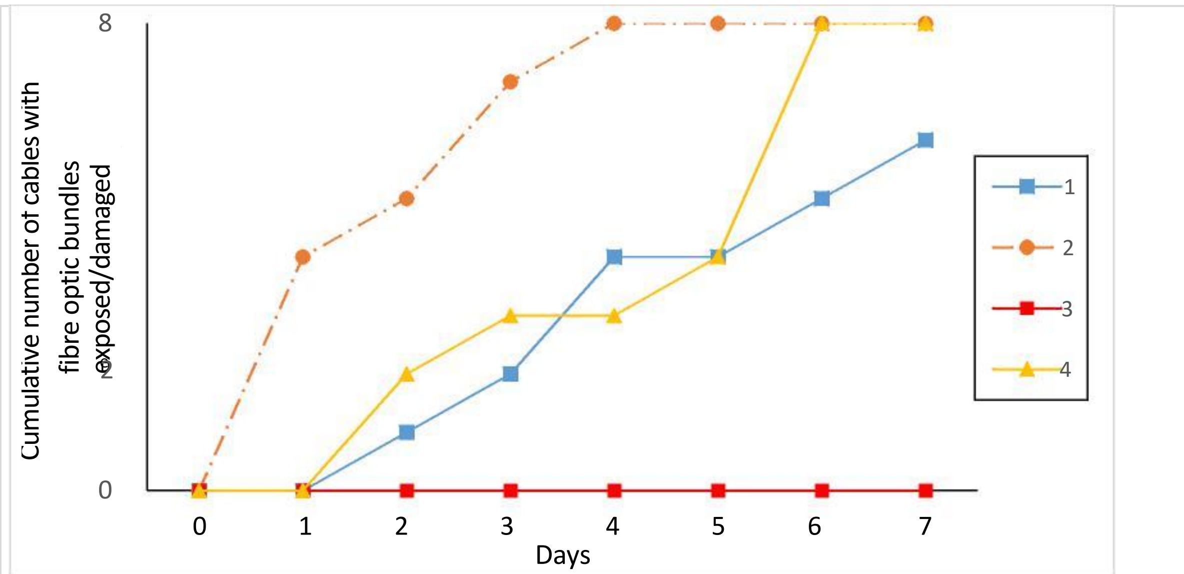

Figure 8. Cumulative tally of the number of cables damaged to the core over the seven-day trial period for the cables '1' to '4'.

Damage to the cables' fibre optic bundles was not significantly affected by the weight of the rats (p=0.557).

Discussion

Our data clearly demonstrates that rodent-proofing is effective in resisting damage caused by rodents in Sample '3', but not the other samples. This sample was markedly more effective than the other cables, and did not incur any damage past its protective layer.

Samples '1', '2' and '4' incurred failure rates of 75% (6 of 8), 100% (8 of 8) and 100% (8 of 8) respectively. A ranking system in the order of decreasing effectiveness in resisting rat damage can be surmised from Figure 7. Columns that have different letters are significantly different, and these can be used to "rank" cables according to their relative effectiveness in resisting rodent damage: cables ranked 'a' are more effective than those ranked 'b'.

The test results did not provide any statistical support for selecting cables within ranks. For example, within rank 'b', it is not known if sample '1' was statistically more effective than sample '2', or if sample '2' was statistically more effective than sample '4'. Testing with a larger sample size (approx. 30 rats) will be required to identify significant differences between the cables within this rank. Results from these further tests will allow for scientifically informed selections between samples '1', '2' and '4', based on statistical significance in the effectiveness of these cables in resisting rat damage.

Sample '3' is a structurally strong, thick and stiff cable with a distinct protective layer, ideal for installation in areas with the highest risk of rats damaging cables, but may be difficult to install and not cost-effective in other situations. If the proposed test with a larger sample size of rats is conducted, Prysmian Group will be able to use the results to determine which of samples '1', '2' and '4' would the more cost-effective cable to use in areas with a moderate risk of rats damaging cables.

Acknowledgements

We would like to thank Chen Yijiao for helping with husbandry and data collection. Experiments were approved under the Animal Ethics permit: SAFS/315/16 (University of Queensland).

Appendix A. Final damage for each cable.

Sample '1': Prysmian SM@RTCORE

Sample '2' : Prysmian LOR@T Fibreglass Woven Tape Rat Resistant Cable

Sample '3': Prysmian NoR@T – GRP Armoured Rodent Proof Cable

Sample '4': Competitor A – Glass Yarn Armoured Rodent Resistant