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PLACOSTYLUS SURVEY, MANAGEMENT AND RESEARCH IN TE PAKI, NORTHLAND

by

Greg Sherley and Richard Parrish

Head Office,
Department of Conservation,
P.O. Box 10-420,
Wellington,
New Zealand

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PLACOSTYLUS SNAIL SURVEY, MANAGEMENTAND RESEARCH IN TE PAKI, NORTHLAND

by Greg Sherley[1] and Richard Parrish[2]

[1]Science & Research Division, Department of Conservation,
P.O. Box 10420, Wellington.

[2]Whangarei Conservancy Office, Department of Conservation,
P.O. Box 842, Whangarei

SUMMARY

This report summarises all known information on the distribution and status of the ten extant subspecies of *Placostylus ambagiosus. P. a. ambagiosus, P. a. consobrinus, P. a. annectens, P. a. watti* and *P. a. whareana* are considered critically endangered. *P. a. paraspiritus, P. a. pandoro, P. a. keenorum,* and *P. a. leslyae* all require urgent management action. While the status of *P. a. michiei* is considered "secure", a management plan is described for it and for the other subspecies. Included in this plan are proposals to eradicate kiore from Motuopao Island (occupied by *P. a. ambagiosus),* to fence three areas where *P. a. annecteus, P. a. kenorum* and *P. a. whareana* are threatened by stock, and to poison rodents on all colonies except Surville Cliffs (P. *a. michiei),* where rodents occur in very low numbers, if at all. The planting of food species and the translocation of all certain subspecies to nearby sites are recommended to augment the above. A timetable for the implementation of snail management follows.

Results show that rats and birds (*Turdus* spp) prey on "middle sized" (sub-adult) snails with rats being the most significant cause of snail mortality (see summary of management issues below). The *P. a. paraspiritus* (Cape Maria van Dieman east = CMVD east) and *P. a. michiei* (Surville Cliffs) colonies should be monitored during rodent poisoning operations, the latter as a "control" since it does not have rodents present. By varying the amount of poison laid each timthe CMVD east colony is treated, it is hoped that a minimum rate of poison application will be found which will allow recruitment of adult snails. We strongly recommend that the currently accepted taxonomic status of the sub species be tested using gel-electrophoresis and that the effect on rat abundance of constructing exclosures and habitat enhancement procedures be monitored.

Summary of management required to secure Placostylus ambagiosus subspecies

SUBSPECIES/ LOCATION	1989 F M A M J J A S O N D	1990 J F M A M J J A S O N D	1991 J F M A M J J A S O N D	1992 J F M A M
Consubrinus CMVD W	Poison 3 month invervals Reveg Taupiri Is	Poison six-month interval on-going & monitor (Sept) subject to plant supply	Poison Taupiri Is and set up rat blockade Introd. 12 snails to Taupiri and repeat if recovery on CMVD permits	Monitor all pops
Paraspit CMVD E	Poison @ 3 mth intervals Translocate 12 snails to each of gullies SE of pa-site Poison rodents prior to release - monitor annually - ongoing	Poison @ six month intervals ongoing Monitor recovery annually in between poisoning (Sept) Repeat quadrat counts		
Ambagiosus Motuopao Is	Poison 3 monthly Prepare rat eradication plan (Motuopao Is) gather materials, prepare revegetation plan Eradication programme starts (see text) Eradication followup " "	Poison six monthly and monitor annually in between poisoning If rat-free start revegetation programme		
Leslyae Scattered Distrbn	Further surveys of early sightings on an opportunistic basis - ongoing.			
Pandora Pandora Beach	Poison for rat @ 3 month intervals Remove remaining four sheep and reveg. as plant supply permits - ongoing.	Poison rats at 6 month intervals and monitor in between times - ongoing (September).		

Summary of management plan (contd)

SUBSPECIES/ LOCATION	1989 F M A M J J A S O N D	1990 J F M A M J J A S O N D	1991 J F M A M J J A S O N D	1992 J F M A M
Keencrum Maungapika West	Poison rats every 3 months Replant food spp. subject to revegetation plan and plant supply.	Poison rats at 6 month intervals and monitor in between times (September).		
Keenrm Maungapika East	Start negotiations with Te Hapua 42 Inc then erect fence and poison, monitor etc.			
Annectens Unuwhao etc	Search for remaining individuals and select fence site. Build fence	Relocate within fence and poison rats (per 6 months) ongoing. Monitor snails and rats as for other sub spp. ongoing.		
Michiei Surville Cliffs	Prepare revegetation plan for Surville Cliffs	Start replant and monitor snails bi-annually.		
Watti Titirangi Point	Search potential localities eg Whiriwhiri (ongoing)		Annual monitoring	Poison rats on Murimoto and set up rat blockade on m/land Transfer 25 snails from the Ivy Wreck area to Murimotu Island
Whareana Whareana	As for annectens			

Note: Of most importance is the order of events rather than the acutal dates - refer to the management/survey/research text for details.
CMVD = Cape Maria van Diemen - east and west

Summary of manament issues for *Placostylus ambigiosus* subspecies

	STATUS				THREATS			MANAGEMENT	
Subspecies	Rare	Frag. Distbn	One locale	Only on muriwhenua land	Rat threat-ened	Pig threat-ened	Stock threat	Fence it	Poison it
consobrinus	Y	N	Y	N	Y	N	N	N	Y
whareana	Y	N	Y	N	Y	Y	N	Y	Y
watti	Y	Y[1]	N[1]	N	Y	Y[1]	N	Y[1]	Y
annectens	Y	Y	N	Y	Y	Y	Y	Y	Y
paraspiritus	N	N	Y	N	Y	N[2]	N	N	Y
michiei	N	Y	N	N	N	N[2]	N	N	N
pandora	Y	N	Y	N	Y	N	Y[3]	N	Y
leslyae	N	Y	N	N	?	Y	N	N	N
ambagiosus	Y	Y[4]	Y[4]	N	Y[5]	N	N	N	Y[5]
keenorum	Y	Y[6]	Y/N[6]	Y[6]	Y	Y/N[6]	Y/N[6]	Y/N[6]	Y

Further survey work is required to determine precisely the distribution of populations and their susceptibility to pig predation.

May be threatened by pig predation if pigs extend their known range.

Removal is required of the five or so sheep which are modifying habitat.

P. a. ambagiosus have fragmented distribution only on Motuopao Island off Cape Maria van Dieman.

Kiore (Rattus exulans) are common on Motuopao Island and probably threaten the survival of *P. a. ambagiosus*. With sufficient planning, kiore may be eradicated from this island.

Two populations occur - one fenced (Maungapika West) while the few animals in the second (Maungapika East) are threatened by stock, pigs and rats. Both sites occur on Muriwhenua owned land.

Note : R. Parrish reports that F. Climo has identified an intermediate subspecies between *P. a leslyae* and *P. a. whareana* which RP collected from Haupatoto Bush.

Turdus spp (thrushes and blackbirds) have been heard or seen and are therefore potential predators on all colonies except *P. a. paraspiritus.* At *P. a. michiei* and *P. a. consobrinus* colonies, anvils have been found.

1. INTRODUCTION

Research plans and management options for *Placostylus ambagiosus* subspecies have been outlined in unpublished reports Sherley and in a thesis (Penniket 1981). In this report we summarise the distribution, current status, predator threats and habitat condition for all ten extant subspecies of *P. ambagiosus* based on data collected during two field trips: 17-28 October 1988 and 30 March to 9 April 1989. Also we report results of research into predation, put a management plan for all subspecies, and recommend further research.

The report is in two parts:-Part A contains the results of survey and recommendations for management action, methods and further research. Management recommendations are summarised and rank-ordered in the report as are the various threats to each subspecies. Part B contains the results of research carried out to date.

Subspecies dealt with in this report were recognised because they were found at Powell's type locality, or at a site nearby. Snails were found also well away from type localities (e.g. Haupatoto Bush), where they displayed characteristics between two subspecies. Consequently, we found Powell's (1979) system of classification unworkable and hence this report deals mainly with the 10 subspecies located at, or nearby, their site of original discovery.

PART A: MANAGEMENT AND SURVEY

1.1 *P. a. consobrinus* (Cape Maria van Dieman West)

Summary
Type locality - Cape Maria van Dieman (CMVD) -eastern side of hill which terminates in the cliff that faces CMVD Island (Powell 1938), grid reference (all grid references below refer to map NZMS 260 M02, NO2): Known distribution - type locality and gully 786475
Current status -probably less than 20 animals
Threats -predators: Ship rat (primary), blackbirds and thrushes (minor).
-habitat modification -possibly grass.

A. Survey.
Searches in two gullies centred on 786473 and 786475 (NZMS 260: M02, N02) produced a few empty shells in the first gully and 5 live snails under hangehange (*Geniostoma lingustrifolia*) bushes mainly in the lower area of the second gully. Four and a half man-hours searching on 26.10.88 produced three adults, one sub-adult and one juvenile. Sub-adults are adult-sized but have not developed a lip while juveniles are smaller than adult-size.

No *P. a. consobrinus* shells eaten by rats were found but they have been reported by Smuts-Kennedy (1988) in the 786473 gully. Large rat middens of *Helix aspersa* snail shells were common in both gullies. Blackbirds occur but pigs are absent and are not likely to range to CMVD west (McLeod pers. comm.). Stock or wild horses are not present.

P. a. consobrinus may be considered rare and probably threatened by rat predation. Fencing is probably not warranted since pigs or stock do not threaten the snails. In the "786475" gully rodent poisoning is warranted: 25 poison stations should be baited as described in Section 2.14.

The systematic monitoring of snail numbers will be difficult because they occur in such low numbers. Comparing snails per man-hour of searching before and after poisoning of rodents should yield a rough measure of the effectiveness of the predator-control programme.

Long-term management should use Taupiri Island (792469) as a location for a second population. If rats occur there, then they need to be eradicated from the island and kept from recolonising by establishing permanent poison stations on the mainland (northern) side of the island. The island is connected to the mainland (CMVD west) at low tides by a sand spit.

Prior to snails being introduced to Taupiri Island, food species (eg hangehange and those mentioned by Penniket 1981) should be planted. No snails should be transferred until the effect of the proposed predator control methods are clear, i.e. until it can be demonstrated that numbers at their present site have increased following poisoning of rodents. Numbers of snails in the wild could be boosted also by captive rearing. Again, however, captive rearing should only be undertaken when the effect of rodent control in their present location is known. The preferred timing of events is outlined in Appendix 4.

1.2 *P. a. paraspiritus* (CMVD East)

Summary
Type locality -on steep seaward face of small rounded headland about one mile south of CMVD (Powell 1951) grid ref 797472.
Known distribution -type locality.
Current status -one population threatened by rats.
Threats -predators : rats (presumed), pigs (potential)
-habitat modification : buffalo grass.

A. Survey
One colony is known from an old pa site (grid ref 797472). Here snails occur in high numbers compared with most other colonies. Pig rooting was seen within a metre of the site, although apparently no snails were taken. The population exists on an "island" since it is surrounded by 250m of bare sand.

B. Management/research
Because the colony is entirely surrounded by sand for at least 500m except for the point of vegetation 250m distant, reinvasion by rats (or mice) after poisoning may be slow. Sand encroachment and erosion may be a problem hence vegetation boundaries should be monitored. Buffalo grass dominates the crown of the hill and may be encroaching on the lower slopes which harbour the snails.

To gauge the effectiveness of rodent poisoning in terms of improved recruitment of snails, live snails and empty shells (preyed on by rats and whole shells) found within quadrats were counted. These counts should be repeated two years after poisoning begins. If poisoning is effective, there should be a significant improvement in the numbers of live snails recorded.

The appearance of the preyed on shells was similar to that described by Penniket (198 1). Results indicate that rat predation accounts for 73% of mortality in this subspecies (Table 1, Part B).

Live snails counted were divided into three age groups, juveniles, sub-adults and adults. A comparison of age distributions of snails found in the quadrats before and after poisoning will also be used to measure the success of the rodent control programme.

Twenty poison stations (sections of novacoil pipe) have been set out and provisioned as described in Section 2.14. The number of baits removed will be recorded each time restocking is done. Initial results of bait take and trapping suggest that the poisoning has reduced rat numbers (Appendix 3).

Future management should entail 3-monthly restocking of poison stations, or at longer intervals depending upon the number of baits removed. The proximity of pigs to the colony should be monitored and those foraging close by destroyed.

Buffalo grass encroachment onto the site of the colony should be monitored and its spread stopped through the planting of shrub species used by snails as food (see Penniket 1981). We consider pohutukawas previously planted on the colony, (genetic origin Taputaputa Bay; Jeffs pers. comm.) to be a potential threat because of the size the trees can grow to, and the consequent modification of the area's shrub community.

Since *P. a. paraspiritus* is comparatively abundant we recommend that translocations be made to coastal sites within 0.5km south east of the colony (eg approximately grid reference 802467). The recommended translocation method is described in Section 2.18, but should only be commenced after rodent control at the new sites has been completed.

1.3 *P. a. ambagiosus* (Motuopao Island)

Summary
Type locality - Motuopao Island Suter (1913)
Current status - extremely rare, less than 10 snails.
Threats -predation (kiore, primary cause), habitat modification (buffalo grass).

Motuopao Island was searched by Richard Parrish, Peter Anderson, Don McKenzie and Lisa Forester between 26 to 28.9.88. Extensive searching revealed three live snails. Kiore (*Rattus exulans)* occur on the island and seven rat preyed-on shells were found. It is certain that kiore prey on P. a. ambagiosus (radulae found in gut contents of one rat) and it appears that they may threaten this subspecies since they occur in relatively high numbers (7 kiore caught in 36 corrected trap nights). Kiore on the c.30 ha island could be exterminated (Graeme Taylor pers. comm. and see poisoning plan in Section 2.14). We recommend that an eradication be implemented in October 1989 when rat numbers are likely to be lowest (McFadden pers. comm.).

A revegetation plan is required for the island which should incorporate food species for *P. a. ambagiosus*.

1.4 *P. a. leslyae* (Te Paki Trig, Darkies Ridge)

Note : This subspecies was described as a sub-fossil (Powell 1979) but was rediscovered on Darkies Ridge in the upper northern catchment of Taputoputo Stream by the NZ Wildlife Service Survey Unit in 1978. The rediscovery was confined by Powell (see file correspondence Wildlife Service file # 33/5/37).

Summary
Type locality -sand dunes at Taputaputa Bay east of Cape Reinga (Powell 1947).
Known distribution - Te Paki trig and spots on Darkies Ridge.
Threats - predators : rats, pigs -relative importance unknown.
Habitat modification : exotic plant species.

A. Survey
Results of recent surveys have been reported by Smuts-Kennedy (1988) and Mayhill (1988). Our survey noted snails (presumably *P. a. leslyae)* from Darkies Ridge, Te Paki Trig and Trig Bush. Generally, a few snails are scattered over a large area. However, further locations of *P. a. leslyae* would be revealed with more search effort.

B. Management/Research
In the Te Paki Trig area we saw no signs of bird, rat or pig predation on snails and no stock sign. However, pigs are known from this area and from Darkies Ridge (McLeod pers. comm.).

Fencing off a population is not warranted because stock do not present a threat. While pigs pose some threat, their occurrence at snail sites appears to be so infrequent that there seems little justification in building a fence to exclude them. Also since this subspecies is so widely scattered, threat of pigs would appear to be Rodents and birds probably take P. *a. leslyae* in parts of its range, but this has not been observed. However, with the snails as widely scattered as they are, we do not see much point poisoning rodents at this stage.

It is possible that P. *a. leslyae* is more widespread than presently known. We recommend more survey work (especially confirming Fred Brookes, Geological Survey, DSIR) sightings to more precisely determine the distribution of *P. a. leslyae.* In the meantime, we do not think they are in any danger that management can materially change.

1.5 *P. a. Pandora* (1km WNW of Pandora)

Summary
Type locality -remnant forest half way up cliff face c.1km west of Pandora Beach.
Known distribution - type locality.
Current status - endangered, probably less than 50
Threats -predators : rats (primary).
-habitat modification : buffalo grass, sheep.

A. Survey
Four adults, four sub-adults and seven juveniles were found at the type locality in about 4 man-hours of searching. The colony's location has been described in Sherley (1988a) and Penniket (1981) except for its area which is 12 x 72m. Five sheep are resident in the area and should be destroyed or removed as they are severely modifying the habitat. No pig sign was seen at the site and apparently they do not occur in the area and should be destroyed or removed as they are severly modifying the habitat. No pig sign was seen at the site and apparently they do not occur I the area (McLeod pers. comm.). Rodents are present (rat preyed shells) as are blackbirds and thrushes (bird preyed shells).

B. Management/Research
Rats have been poisoned: 20 stations were arranged throughout the colony's site and baited in the manner described for *P. a. paraspiritus.* Poisoning success was monitored by recording bait take and conducting trapping done so that poisoning success could be monitored. Rat and hedgehog trapping is described in Part B of this report. No rats were caught suggesting that the poisoning to date has been successful.

One hedgehog and one cat were caught. Hedgehogs may be predators of snails, hence the stomach contents were removed and examined for snail remains but none were found. It may be necessary to keep a watch on the number of hedgehogs on colonies, especially if numbers of snails increase in years to come.

The trapping results the conclusion that the low level of bait removal (see Appendix 2) is a consequence of most of the rats about the colony being poisoned.

Kikkuyu grass is modifying habitat and its control is warranted. The habitat would benefit from planting hange hange, *Coprosma macrocarpa, C. grandifolia* (as shrubs) and kohekohe as canopy. Tawapou and karaka may regenerate in the absence of stock.

1.6 *P. a. keenorum* (Maungapika)

Summary
Type locality -Maungapika east (Powell 1947).
Known distribution -Maungapika west and east.
Current status -probably less than 50 snails.
Threats -predators (both colonies) primarily rats
-habitat modification : kikkuyu grass, stock browse.

A. Survey
There are two populations on Maungapika hill - one on each side. On Maungapika west (grid ref 982534), 14 snails were found in 8 man-hours of searching on 10.10.88. The fence built by Save Our Snails (SOS) Society is still in good condition, though in future it will require a lot of maintenance as the feed for stock inside increases relative to that outside. On 4.4.89 three sheep were found inside the exclosure having gained access through a hole in the fence. Rat middens were found and blackbirds were heard.

Snails were also found on the eastern side of the hill in the water course amongst the *Doodia* sp. (grid ref 984534). This area is a remnant patch of kohekohe, *Cordyline australis, Carmachaelia* sp. and mahoe dominated forest. Three live adults and three dead sub-adults (whole shells) were found in four man-hours of searching.

Two pig-preyed on shells were found on the east-side population –only the aperture remaining. The forest area which contains the population (snails were searched for outside) measures approximately 50m x 30m. The land is owned by the Te Hapua 42 Incorporation who have allowed the Maungapika west colony to be fenced off.

B. Research/Management
After sufficient fencing materials have been procured, we recommend that negotiations be started with Mr Matiu Rata, Komatua of the Muriwhenua, to allow the Department to construct a rectangular fence around the mature forest remnant on the east side of Maungapika to protect the remaining snails from stock and pigs. When this is done, monitoring should be undertaken to check the extent of adult recruitment.

Trapping at Maungapika West showed that rats and stoats were present (see Part B results and Appendix 3). Trapping subsequent to poisoning was unsuccessful suggesting that the poisoning was effective in reducing rat numbers (0 rats for 20 corrected trap nights on 20.6.89, using Fenn traps; Appendix 3). Research is required to continue to the response of the snails to removing rodent predation (see Section 2.17 for research recommendations and Part B for research results).

Maungapika west colony has been poisoned for rats (10.4.89) using the same poison restocking rate mentioned earlier. Bait removal data occur in Appendix 2.

In Maungapika west we attempted quadrat and point based counting of snails along transects, however, the data obtained were meaningless because there were so few snails. Thus we do not intend using this colony to monitor the effects of rodent poisoning on snail numbers. However, the colony will be used to monitor rat numbers before and after poisoning since it is so accessible.

Possibilities of monitoring live to empty shells have been compromised in the Maungapika west area because some "restocking" with old (dead) shells has been done in the past (Bill McLeod pers. comm.). Also, we found there empty shells of *Powelliphanta hochstetteri bicolor* and *P. h. consobrina* (Kath Walker, pers. comm.) which are only from the eastern Marlborough Sounds. Andrew Penniket (pers. comm.) introduced these as empty shells.

Since kikkuyu grass is over-running a large proportion of the colony, we recommend planting food species from local genetic stock: canopy -kohekohe, mahoe, karaka, wharangi; shrubs- hangehange, *C. macrocarpa, C. grandifolia* and kawakawa. Advice should be sought from a botanist to detennine whether spraying kikkuyu is required around the transplanted trees to allow them to establish without being overgrown. If the eastern colony is fenced, regeneration in the absence of stock should adequate.

1.7 *P. a. annectens* (Unuwhao and other areas within Muriwhenua land)

Summary
Type locality -Unuwhao at 270m ASL (Powell 1938)
Known distribution - scattered reports.
Current status - extremely rare.
Threats - rats, stock and pigs (no priority).
Habitat modification -pig damage (Kath Walker pers. comm.).

A. Survey
In our surveys, *P. a. annectens* was not found, though it is known to exist at a number of localities between Hooper Point and Tom Bowling Bay (west) including Unuwhao. This subspecies has a fragmented distribution (see Smuts Kennedy 1988) and probably survives in extremely low numbers. Some time was spent searching for a suitable area for enclosures within the known range of *P. a. annectens.* Two were identified:

1. In forest located in the upper third of the Te Huka Stream in one of its true left tributaries (NZMS260, MO2 grid ref 037523). The main canopy tree species present were pohutakawa, karaka, kanuka, *Coprosma arborea,* rewarewa, puriri, taraire and some kohekohe. The area has a slope of about 10o and was quite damp underfoot (22/10/88). Minimal damage from stock occurs but pig sign was common. Confirmation that this area does (or did) harbour *P. a. annectens* was providing by finding shell fragments and one complete shell (c. 70mm long).

2. The second area is located almost opposite the first on the same ridge at grid ref 031526. The main forest species present were similar to those at the first, but the diversity was more extensive, including melicope, hange hange, *Quintinia* sp. and puriri. Regeneration is prolific and no stock or pig sign was found. No shells were found although the area was not intensively searched. The area is virtually flat, damp under foot and should be easy to fence.

Either of these areas would be suitable for introducing snails. They are within 150m of a 4 wheel-drive road and therefore easy to access. Enclosures would have to be stocked by collecting snails from surrounding areas.

B. Management/Research
Option 1: Collect as many snails as possible from their existing range and introduce them into an enclosure located in one or both of the locations described. The enclosures should be either fully rat-proofed (totally enclosed) or at least stock and pig proof and rodents poisoned.

Option 2: Using volunteers, survey the entire known range and mark locations where snails are found. Then divide the located snails into two groups: those to be protected by a high quality pig and stock proof fence and those to be left *in situ.* The former group (about half the total and probably less than 20 individuals) should be identified on the basis of natural clustering (likely to occur) so that the number have to be relocated inside the fence, and the latter "half' identified as those that are most widely dispersed as singles or pairs and do not warrant moving.

Planting and rat-poison stations should be established in the fenced area. The scattered snails left *in situ* would be marked and monitored and rats in the vicinity controlled with poison stations. If after two years the fenced snails survive and breed, then the possibility of moving the remaining snails inside the fence should be considered.

We recommend option two since it does not mean relying solely on one method and involves minimum disturbance to snails. Longer term management (timing dependant on monitoring results) will involve relocating individuals from the enclosure to sites where snails were previously known to occur.

1.8 *P. a. michiei* (Surville Cliffs).

Summary
Type locality – Kerr Point near eastern margin of the herbfield and only along the coastal ridge (Powell 1951).
Known distribution – Surville Cliffs area.
Current status - one large relatively secure population.
Threats - some bird predation, pigs pose remote threat
- dispersal potential in dessicating environment.

A. Survey
P. a. michiei is one of the two most abundant subspecies (*P. a. paraspiritus* is the other). New localities were searched to determine the extent of its range. Two potential forest patches were identified between Surville Cliffs and Kerr Point (centred on grid references 107552 and 110553). The forest canopy was dominated by pohutukawa with hangehange and rangiora as common understory species. The latter patch of forest was of poorer quality. However, no snails or shells were found in either. The coast from Mahurangi Point to Kerr Point did not appear to have any habitat which resembled Powell's description of the type locality of *P. a. michiei*. Hence the type locality (if it can be found) remains to be checked.

It is conceivable that the range of *P. a. watti* and and *P. a. michiei* overlap, hence in future Department of Conservation will have to check the taxonomic status of snails found near Pararaki Stream as these could belong to either subspecies.

B. Research/Management
A search for at-preyed on shells was made in twelve 2m x 2m quadrats marked out on the flat cliff-top area and rat-induced mortality was scored 9see Table 2, Part B for methods and results). No rat eaten shells were found which suggested that rats are not present (cf Penniket 1981 who notes their presence), and therefore poisoning is not required.

Most snail mortality was probably due to factors other than predation since all but one empty shell was whole. However, outside the quadrats, four *Turdus* species "anvils" were found with *Placostylus ambagiosus* shells (all sub-adults or younger) surrounding them. Subsequently, on 1.4.89 we collected bird preyed on shells mainly from anvils within the colony area and found that, as with rodents, birds took mainly juvenile snails (see Part B of this report).

While it may seem desirable to control blackbirds and thrushes, *P. a. michiei* is recruiting adults into the population (as evidenced by numbers of sub-adults, Part B Table 2). Hence predator control is not required, especially when the management of some of the other subspecies is so urgent.

If pigs 'discovered' the Surville Cliffs snail population we believe it would be disastrous. Yet there is little to attract them although they have been seen within 500m of the surveyed colony. A fence would not protect all the snails and the visual impact of one would seriously impair the quality of the area which is a Scientific Reserve. We suggest the best compromise is to maintain a watch on pig movements and eradicate any that come too close.

We recommend planting hangehange (from local genetic stock) so that the present range of hange hange, around which the colony is based, is extended parallel to the main access road. Snails should then be translocated to the new limits of hangehange. The track which runs at right angles northwards from the main access road and bisects the colony should also be planted with hangehange and other local shrubs to extend the area of habitat. Planting the track will, in time, remove a source of mortality since the road acts as a trap for dispersing snails which get caught out in day-time and die of dessication or over-heating.

If the translocations described above are successful, the distribution of this subspecies could be further increased by moving snails to hangehange bushes on the serpentine quarry side of the main access road.

1.9 *P. a. watti* (North Cape area)

Summary
Type locality -Mid-way between Waikuku Beach and North Cape lighthouse at 3 to 8 metres ASL and 7 to 55 metres back from boulder strewn beach (Powell 1947).
Known distribution - Titirangi Point and coastal points WSW for approximately 2km.
Current status -very rare.
Threats -rat predation (primary), pigs.

A. Survey
Part of the historically known distribution was searched over 3 man-days in October 1988 : Murimotu Island (presumed to occur there once); the coast SW of Titirangi Point to the first stream and associated remnant forest, uphill to the leading spur to Titirangi Point; and all coastal forest remnants NW of Titirangi Point to the gully before Pararaki Stream.

Rat-preyed on shells and one live juvenile were found under an association of *Coprosma robusta/Astelia* sp. and *Phormium tenax* (i.e. not in a forest situation) at about grid reference 152543. A patch of remnant forest centred on grid ref 148543 yielded only two empty shells. Similarly, two empty adult shells were found on the search NW from Titirangi Point -one in each of the last north eastern most remnant forest patches near Pararaki Stream (grid refs 142551, 144549). Although regeneration is excellent, these areas of forest had suffered extensive pig damage. The regeneration of vegetation in these areas is being compromised by the effects of foraging pigs.

Murimotu Island was searched in 3 man-hours. Most effort was spent on the slopes facing the mainland. A small *Cordyline sp.* 'forest' occurs in a basin along with flax and hangehange while most of the island consists of flax, hangehange and introduced grasses. No sign of snails or rats were found.

On 30 and 3 1.3.89, the bushed areas centred on the three about grid reference 142540 (hence within 300m of the shore) were searched. One adult, 1 sub-adult and 2 juvenile snails were found alive in 4 man-hours searching. Over the rest of the area at least four man-hours revealed no shells except some scattered empty shells within 50m of the coast east of the grid reference above.

Two areas remain to be surveyed: (i) from the outlet of Te Whiriwhiri Stream up to the end of the secondary forest (stream outlet grid ref 134538), and (ii) the unnamed stream whose outlet is located at grid reference 148542. This should be done before a decision is made on where to fence.

B. Management/Research
Whole and rat preyed on shells were collected. As with the other subspecies, rats took mainly larger juveniles, whereas whole shells were mostly very small juveniles or adults (see Part B results).

This subspecies appears to have a fragmented distribution and very rare. Penniket (1981) considered *P. a. watti* to be "numerically very strong" -by implication as numerous as *P. a. michiei* and *P. a. keenorum.* It appears therefore, that *P. a. watti* has declined dramatically since his surveys.

We recommend poisoning for rats on the colony about grid reference 142542 in the manner described for *P. a. paraspiritus* (fifteen stations should be sufficient). These should be placed at the periphery of the colony to damage to snails from trampling when stations are restocked. When snails have recovered sufficiently (determined from annual monitoring e.g. fixed quadrats or search success rate index), Murimotu Island should be prepared to receive translocations. Preparation should involve poisoning to "eradicate" rodents. We do not envisage true eradication since Murimotu is permanently connected to Titirangi Point by an isthmus of shingle about 150m long. However, the incidence of re-invasions by rodents could be reduced by setting up a "barrier" of poison stations (about 20), on the mainland end of the isthmus. Once the island is virtually rodent free and snails occur in adequate numbers on the mainland, translocations should be made. The survival and location of transferred snails must be monitored.

1.10 *P. a. whareana*

Summary
Type locality -in a steep valley north of Whareana Stream (Powell 1951).
Known distribution -last seen at Whareana
Current status – extremely rare.
Threats - predation (rats and possibly pigs).
-stock (potentially).

A. Survey
On 27/7/88 one juvenile was found in the lower Whareana Stream catchment (grid ref 106489) in three man-hours of searching. This is the only area where *P. a. whareana* are known to survive. Forest dominants were kohekohe, karaka and kanuka while the understorey consisted mainly of

rangiora and kohekohe. The detritus layer was poorly developed, and small amounts of stock and pig sign occurred throughout. Numerous old dead shells were found, including some that had been eaten by rats. However, numerous whole juvenile shells were also found. In our opinion, this subspecies is critically endangered, especially since it occurs in extremely low numbers at only one site.

B. Management/Research
We recommend the same management action to take place for a *P. a. whareana* as for *P. a. annectens* i.e. fencing off the bulk of remaining snails and poisoning rodents, and poisoning within the vicinity of remaining scattered individuals.

1.11 *P. a. hancoxi*

Summary
Type locality -Te Topito Head (Powell 1938).
Known distribution -unknown.
Current status -unknown.
Threats -unknown.

A. Survey
The subspecies *P. a. hancoxi,* was described from Te Topito Head by Powell (1938), but never mentioned subsequently by him. It is possible that he dropped this classification from consideration. Penniket (1976) states only one live snail was found and very little remains. Pig predation is evident. The population has never been large (H. Seals pers. comm.) but seems in imminent danger of extinction". Gardner and Adams (1977) state "only one was found...". We did not attempt to search for this subspecies because of its doubtful status and the vagaries of its recorded locations. We suggest that consideration of this subspecies be "shelved until the Department has completed management tasks on the other subspecies.

1.12 General recommendations for management of *Placostylus* snails

a) Fire : A fire management plan for Te Paki Farm Park should recommend priority be given to protecting known snail colonies. If possible fenced areas should be protected with firebreaks, but these should not compromise the quality of the snail habitat or risk erosion.

b) Translocations : Can be considered seriously since at least one of the early Wildlife Service translocations is now known to have been successful (see Parrish 1989). For example three snails still survived on Motutakupu Island (Cavalli group) in March 1989.

1.13 Fencing materials

Three enclosures have been recommended for *Placostylus ambagiosus* subspecies protection: one each for *P. a. annectens, P. a. whareana* and *P. a. keenorum* (east). In each, habitat enhancement will be required involving planting food species and rodent control. In the case of *P. a. keenorum* (east) (and for all colonies of *P. a. annectens*) the land is owned by the Muriwhenua. Before negotiations are started to fence the area (which we believe would be successful), the Department should ensure that it has the materials.

Each fence: rectangular 100m x 50m.
4 strainers, 4m per post, 1 waratah per metre.
300m hurricane wire.
600m #8 aluminium wire.
box staples (1 for all three).

Totals (3 fences): 12 strainers, 220 posts, 475 waratahs.
1900m hurricane wire.
1800m #8 aluminium wire.
box of staples.

1.14 Poisoning rodents at *Placostylus ambagiosus* colonies.

Baits will be made available to rodents at intervals of time (pulse baiting regime). We have presented an estimate which will vary on the bait removals, possibly location, and assumes all bait is gone or destroyed every 3 months.

a) 6 baits per station
b) Rebait after 1 week.
c) Rebait again after 2 weeks.
d) Rebait again after 2-3 month intervals.
e) stations ideally Talon WB black plastic ready made but pipe would be adequate.

Recommendations.

If rat numbers (derived from trap-monitoring) are sufficiently low enough to allow snail recruitment with the 2-3 month restocking regime, then rebaiting twice a year is recommended with monitoring in between i.e. in September and late March, trap in July. Trapping results should reveal next to zero indices before considering less frequent rebaiting. We recommend using one of the anticoagulant (e.g. Brodifacoum) poisons in cereal which is embedded in a wax matrix pellet.

Below we have estimated the quantities of Talon WB (Brodifacoum 0.05%) required for one years poisoning assuming stocking for one station for one year requires 36 standard egg sized baits (lkg). Talon has been used to date successfully.

	N. stations	Kg bait for 1st year	Following years
Consobrinus	25	25	16
Paraspiritus	20	20	12
Whareana	50	50	34
Watti	50[1]	50[1]	34
Annectens	50	50	34
Pandora	20	20	12
? subsp @ Pandora	27	50	34
	265	265	176

1 -will depend on the area to be poisoned.

1.15 *Placostylus hongii* (Whangaruru North Head SR)

We were asked by Dave Hunt and Shaughan Anderson to assess the status of the Whangaruru North Head Scenic Reserve population of *Placostylus hongii*. We believe this population will be threatened by vegetation modification brought about by the recent possum invasion. The aim of our study is to monitor any changes in the abundance of shells and score mortality due to (i) rats, (ii) birds and (iii) other factors (whole dead shells).

On 10.4.89 four 10m x 1.5m quadrats were established in representative forest of the reserve (a map showing locations is on file at Conservation Sciences Centre and Whangarei Conservancy Offices). These quadrats will be monitored by field staff annually by counting and measuring all live snails amd removing empty shells for measurement. Care was taken to replace live snails at their site of capture and to return the litter to its original state as far as possible.

Note

a) Juveniles are snails smaller than adult length and without any lip formation.
b) Sub-adults are snails of adult length but without a lip around the aperture.
c) Adults are mature shells with a calcified lip around the aperture.

Table: Live snails found in quadrats at Whangaruru North Head Scenic Reserve on 10.4.89.

	Maximum overall length	
Quad #	Juveniles (mm)	Adults (mm)
1	33.35, 40.20	72.90, 78.30
2	8.00	81.20, 75.20, 70.05, 76.30*
3	14.45, 10.50, 9.75, 15.85, 18.05, 6.95, 16.05, 10.20, 17.05, 24.05, 23.90, 25.90, 7.50, 18.80	78.95, 76.20, 75.25, 78.50, 75.20, 80.90
4	34.95, 9.25, 31.35, 16.35	77.40, 75.90, 81.45, 79.45
Total	21	16

* = this snail was marked from a previous study (see below) as 'K1'
Note : No live sub-adult snails were found

Penniket (1981) has undertaken research at Whangaruru in the past and some of his circular plots still remain. Quadrat 2 is about 4 metres from one of these, hence it was not surprising to find two marked snails surviving from his research. Three observations of marked snails were made : (1) "Kl" was found in quadrat 2 - its release site after marking is unknown, (2) snail #43 was seen alive 3m from #9 circular plot pole and (3) Snail #37 was seen alive 6.8m from #9 circular plot pole indicating that the snail had moved at least four metres from its original capture/mark site (circular plot radii were less than 3.1m).

In vegetation encountered along the route between the quadrats, about 15 juvenile (less than 4mm) *hongii* snails were found alive in casual observations on palm foliage. In the latter they were especially common of the fronds and stem. The inference is that upon hatching P. *hongii* snails are aboreal.

Recommendation.
The quadrats should be scored annually in April. Data should be analysed to determine if there is any change in the age distribution of snails and any significant changes in their density. Data from this study should reveal whether or not the population is stable.

1.16. Eradications of kiore (*Rattus exulans*) from Motuopao Island (offshore from Cape Maria van Dieman).

Motuopao Island is the type locality for *P. a. ambagiosus.* It is approximately 30 Ha and consists of two hillocks linked by a low saddle. Strong currents and a dangerous wave action make the island's one sandy beach difficult to land on. Hence, despite the island only being about 500m from Cape Maria van Dieman, reliable and safe access to the island requires a helicopter.

Kiore could be eradicated from Motuopao Island given the Department's willingness to invest sufficient manpower, time and money. Here we outline a plan exclusive of personnel travel and time spent on organisation. An estimate of man-days on the island can be made, but time spent there will depend on the success of the first poisoning effort. Also, trapping will be required following poisoning to check if kiore still survive -the costs of traps and trapping time are also ommitted.

Method.

Automatic feed dispensing silos (McFadden 1984) should be distributed evenly over the island at about one per $50m^2$. If necessary an area of about $1m^2$ should be cleared around each silo to ease finding them. When the silos have been set out they should be filled with non-toxic bait such as kibbled grain. After the fourth night the pre-feed should be replaced with toxic kibbled grain (eg maize, but it must be the same grain as used in pre-feed), which Rentokill can provide (using the anticoagulant Bromodialone). The process should be repeated after 4 to 6 weeks if kiore still survive. The presence of rats can be determined by trapping or noting bait removal from silos or containers holding non-toxic bait. Poisoning should continue until trapping indicates kiore have been exterminated.

Resources.

Two hundred automatic dispensing silos (estimate) will be required but we are sure many of these already exist within the Department and may be borrowed. Four sacks of kibbled maize should be adequate (one sack supplies about 50 silos) and a further two sacks kibbled maize mixed with Bromodialone.

Manpower - (i) Initial work : four people for ten days on the island to set out stations and carry out the initial poisoning; (ii) Follow up : two people for five days on the island for prefeed, poisoning and trapping.

1.17 Further research on *Placostylus* snails

A. Assessment of the taxonomic relationships within and between subspecies of *Placostylus ambagiosus* and *P. bollonsi,* and their relationship to *P. hongii* using gel-electrophoresis.

Status: Not started or approved at time of writing.

Aim: to identify genetically discrete populations of the *Placostylus* subspecies complexes *(P. ambagiosus* and *P. bollonsi)* and their distinction from *P. hongii,* and hence rank-order management activities.

Methods : (1) collect up to five of *P. hongii* and, if possible, two individuals of each subspecies of *P. ambagiosus* and *P. bollonsi.* However, those subspecies which are extremely rare would not be collected.

(2) use standard gel-electrophoresis methods to clarify the taxonomic status of the various *P. ambagiosus* subspecies. In instances subspecies separations may not be justified, while in others genetic analysis may reveal "subspecies" to be separate species. Implications for management are obvious. We recommend this work because we have found Powell's criteria for separating taxa unworkable, especially for the newly discovered populations near Pandora and Haupatoto.

P. bollonsi (which has several recognised subspecies) is included under request from management because its subspecies may need rank-ordered managment. Further by including *P. bollonsi* and *P. hongii,* two outlying groups (relative to *P. ambagiosus)* are provided. These will allow a basis for comparison to make decisions on what constitutes genuine specific and subspecific variability, especially since P. *bollonsi* also consists of a subspecies complex.

B. Determination of the response of *Placostylus* to rodent control (see also Sherley 1988a).

Status: approved research proposal and underway at present.

Aim: To determine: (1) the impact rodent predation has on snail populations, (2) the poisoning regime that most efficiently reduces rodent and its effect on snail numbers and (3) if fencing-out stock and enhancing snail habitat within these enclosures increases rodent numbers.

Methods, rationale and product: Quadrat based (2m x 2m) counts of live snails and empty shells (both damaged and whole), have been collected from *P. a. michiei* and *P. a. paraspiritus* colonies to form a data base to compare the age distributions of the populations before and after two years of poisoning. Two years is the time taken for hatchlings to reach sub-adult size (Norman Douglas pers. comm.) although this is disputed by Andrew Penniket (pers. comm.) who claims the time is 5-7 years.

The *P. a.* population, which is free of rat predation, acts as a control. The results of this study will supply information on the minimum poisoning rate required that will enable snails to recruit adults.

Study of the influence of fencing and of enhancing snail habitat on rodent numbers has not been tackled because no enclosures have been constructed at the time of writing.

1.18 Methods for translocation of *Placostylus ambagiosus*

1. How many snails?
Depends upon numbers in the parent population, although generally 12 adults should be moved at any time.

2. What time of the year?
Late (May onwards) depending on local season i.e. if season is dry then translocation until later in the year. Moving in winter will the minimise the risk of dessication.

3. How?
Snails should be individually marked as follows: file off enough of the periostracum near the lip to allow marking (in indian ink) a binary number (e.g. up to seven pairs) by recording the "zeros" and "ones" as "dots" and "dashes" respectively. After the ink is dry the number should be painted over with clear nail varnish or similar. Using binary numbers should lessen the chances of mistaking numbers in future.

4. Where?
Snails should be placed under a food species and within an area supporting a vegetation community as similar as possible to that of their original habitat. Duration of movements should be as short as possible (preferably one day, but less than 3). In transit, snails should be kept in ventilated, moist soil/litter boxes in darkness to avoid desiccation and disruption. Animals should be released in groups, if necessary all 12 could be placed under one bush. When introducing snails to new sites avoid exposing them to the risk of desiccation or overheating. The release site should be marked with a peg. A written description of the site and a grid reference should be recorded on file.

5. Follow-up
Snails should be monitored at four-month intervals for the first year, then six-monthly for the next two years. Thereafter, annual monitoring should suffice. Monitoring should include scoring survival, location (i.e. movement from release-site) and noting new individuals (includes labelling recruited adults).

Note
1. Juveniles translocated should not be marked because of risk of damage. Sub-adults may be marked as for adults.
2. Although a of methods for marking have been tried by researchers, we consider the method indicated the most reliable long-term. However, remarking will be required periodically.

1.19 Location of new colony near Pandora

On 8.4.89 a check was made of a new colony reported by John McCullum: 30 juveniles, 7 subadults and 16 adults were found during 4.5 man-hours. The area searched was centred on grid reference 879508, about 0.5km in a straight line NNW of the Pandora beach colony. Snails were found on the true right of the stream between two waterfalls, one at the coast and the other about 400m upstream. The colony covers an area about 300m x 100m - the "long" side of the rectangle running along the bed. Near the top waterfall there is an obvious patch of mature pohutukawa dominated forest on the true right: the colony starts from here running downstream. A hand-drawn sketch is on file at the Conservation Sciences Centre and Whangarei Conservancy Offices. Numerous rat preyed on shells were found so rodent control should improve snail numbers.

Inspection of the National Museum collection and consultation with Dr Frank Climo have failed to reveal the identity of individuals from this new colony, but they resemble closely *P. a. leslyae,* and to a lesser degree *P. a. pandora* and *P. a. keenorum.* In size this colony is on par with the *P. a. paraspiritus* colony at Cape Maria van east. Therefore its true subspecific identity should be determined urgently (see Section 2.17).

1.20 Search of other areas

Kohuranaki.
On 4.4.89 the stream catchment SSW of Kohuranaki trig (958459) and marked as bush on the NZMS 260, was searched in 4 man-hours. We also searched the bushed areas marked within a 180° arc about the pa site near the trig in 4 man-hours. No *Placostylus* shells were found but 9 *Paryphanta busbyi watti* empty shells were seen on the track centred on 955454.

PART B: CURRENT RESEARCH ON *PLACOSTYLUS*

1. INTRODUCTION

Work currently underway is aimed at determining the minimum level of poisoning required to allow recruitment in snail populations. This in turn, has required us to identify predators of *Placostylus* snails (see management text, Part A Sections 2.12 and 2.17), to determine levels of predation prior to poisoning (this section), and to gauge constituted mortality due to "natural" factors. These data were required to enable us to assess the effectiveness of poisoning at given rates.

In addition, the population of *Placostylus hongii* at Whangaruru North Head Scenic Reserve is being monitored to assess if its density will decline with the arrival of possums in the reserve.

2. METHODS

2.1 General methods

A "before and after" type experiment has been set up at Cape Maria van Dieman east which involves poisoning at a given rate (see later) for two years (the approximate time for snail hatchlings to reach sub-adult size) after which time the quadrat counts are repeated. As a control (no rats present), the Surville Cliffs population (*P. a. michiei*) will be monitored by counting snails at the sane times.

Poisoning has adopted the "pulse" baiting technique. The following rate will be altered upward or downward after two years depending on results of rat monitoring and snail survival. Hence a minimal level will be found that still allows recruitment of snails.

(1) 6 baits per station
(2) rebait after 7-10 days
(3) rebait again after 14 days
(4) rebait again after 2-3 months
(5) continue rebaiting at 2-3 month intervals

Bait used is Talon WB (Brodifacoum 0.5%) -an anti-coagulent in kibbled wheat set in a wax matrix.

The reason an interval is referred to in some rat preyed on data and not a discrete value is because rat eaten shells from Maungapika were too broken to sensibly measure length overall. Instead shells were "fitted (by shape) into size categories which conformed to the actual size of whole shells. This is also why graphs from Figure 3 onwards of preyed on shells have intervals on the abscissa, as opposed to discrete midpoints of intervals for whole shells whose length could be precisely measured.

2.2 Specific methodology for subspecies

P. a. paraspiritus (CMVD east)
Twelve 2m x 2m quadrats were searched: 6 on 21 October, and 6 on 25 October 1988 (see Part A for location). Live snails were recorded as juveniles (less than adult length = 60mm), sub-adult (adult length but no lip) and adults (lip formed).

They were returned as quickly as possible where they were found and the vegetation "reconstituted" as best as possible. Empty shells (whole and rodent-eaten) were collected and removed for later Rodent eaten shells were measured to the nearest 1mm and “fitted” into 5, 15mm categories (see Figure 1). Whole shells were measured to the nearest Empty Helix shells were also collected.

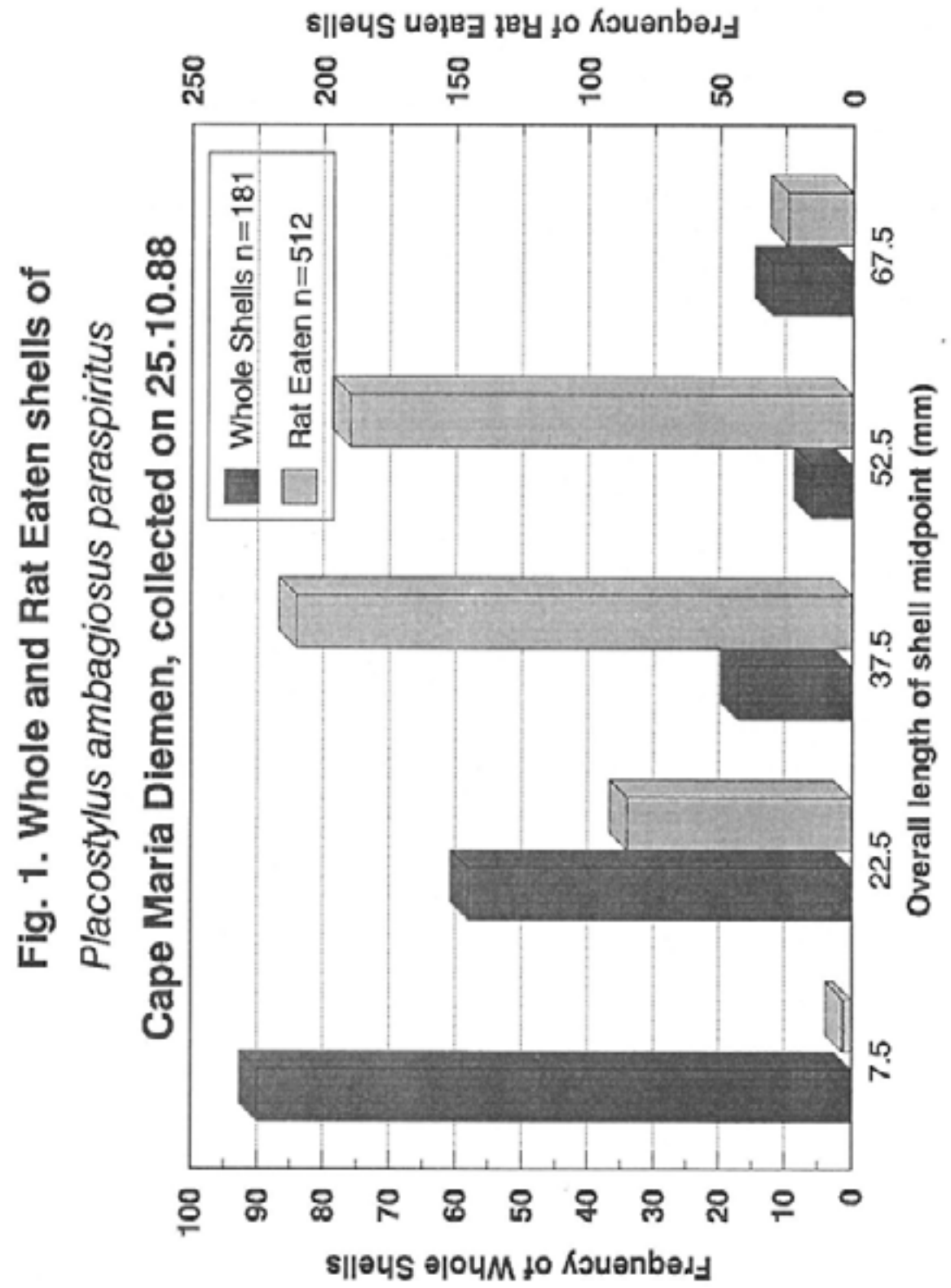


Fig. 1. Whole and Rat Eaten shells of
Placostylus ambagiosus paraspiritus
Cape Maria Diemen, collected on 25.10.88

P. a. michiei
Twelve 2m x 2m quadrats were sampled as described for *P. a. paraspiritus.* However, rodents do not appear to be present at the site of this colony, the only introduced predator being blackbirds and/or thrushes. In order to assess which size classes of snail these birds took, we searched the colony for anvils and collected what shells we could from them and any others we found lying about.

P. ambagiosus n. subsp. (near Pandora) and *P. a. watti*
When searching these colonies, we collected and removed all dead shells we could find to determine whether rats were significant predators.

Placostylus hongii
Four 1.5m x 12m quadrats have been established in typical forest within the range of the snails. They can be best searched without trampling with two people working along the long side of the "quadrat" and "reaching in" and a third person recording. Dead shells have been collected and live ones measured to the nearest 0.1mm- longest dimension (referred to as "overall length of shell" on figures).

3. RESULTS

3.1 Age distribution of empty shells (shells not preyed on by birds or rats), and shells preyed on by rats and birds.

3.1.1 *P. a. paraspiritus* (CMVD east)

Note:-Smaller snails (approximately <15mm) may be attacked by *Rhytidarex duplicata* (a small predatory snail). However, *R. duplicata* is known not to occur at CMVD east *(P. a. paraspiritus)* (survey carried out incidentally, this study).

The average size of whole shells (snails dying of "natural" causes) collected off the 12 quadrats was 20.6mm (SD=15.6, n=181; median=15.3). Shells eaten by rats (or possibly mice) were significantly larger (x=42.3mm, SD=11.7, n=512, median=42.3mm; T test, P= 0.001). It would thus seem that rats selectively prey on older animlas (Fig 1). The "age category" represented by the size 42.3mm is that of animals close to adult size but sexually immature (without an aperture lip). If the data of whole and rat preyed on shells are grouped in the same intervals and their frequency distributions compared using Chi-square, the hypothesis that the distributions are similar is rejected (P <0.001).

Thus snails are being preyed on by rats before reaching breeding age. Rats, or rodents, are the most important mortality factor at CMVD east accounting for 73% of snail losses (Table 1). Similarly, in the same area, rats (or mice) were responsible for 74% of mortality of *Helix aspersa* (Appendix 1).

Table 1: Mortality of *P. a. paraspiritus* on 2m x 2m quadrats, CMVD east, Te Paki Farm Park

Quad	Rat eaten		Bird eaten		Whole shells			Total	
	Ad.	SA+J	Ad.	SA+J	Ad.	SA	J	Ad.	SA+J
1	0	66	0	0	2	1	2	2	69
2	0	122	0	0	0	0	0	0	122
3	0	4	0	0	0	0	2	0	6
4	0	8	0	0	0	0	0	0	8
5	0	81	0	3	0	1	10	0	95
6	0	89	0	0	2	2	14	2	105
7	0	38	0	0	0	0	0	0	38
8	0	28	0	4	2	24		2	57
9	0	22	0	0	0	0	19	0	41
10	0	40	0	0	2	1	32	2	73
11	0	61	0	0	0	2	94	0	157
12	0	50	0	0	0	2	0	0	52
Subtotal	0	609	0	7	8	33	174	8	823

Notes:

1. Sub-adults and juveniles data are grouped in 'rat' and 'bird' categories since rat or bird eaten shells could not usually be differentiated.
2. Whole shells -mortality due to unknown causes, dessiccation.
3. Adult -shell with lip at least partially size but no lip, juvenile -shell with no lip and smaller than adult rats took predominantly sub-adult snails was supported by the low number of live sub-adults found in the quadrats (Table 2).

Quad	Adult	Sub-adult	Juvenile	Total
1	3	0	0	3
2	2	0	0	2
3	0	1	1	2
4	0	0	0	0
5	24	2	12	38
6	10*	0	3	13
7	0	0	0	0
8	7	0	3	13
9	1	0	7	8
10	1	0	4	5
11	14	0	25	39
12	3	0	0	3
Total	65 (53%)	3(2%)	55 (45%)	123

* recapture of marked snail

These live snail figures compare Penniket's (1981) who found 13 at this area in 1979, of which only one was a sub-adult.

3.1.2 *P. ambagiosus* new sub sp (near Pandora, see Part a section 2.19)
The median size class of shells eaten by rats was 31-45mm whereas most of the "natural" mortality occurred in the younger age classes (x=20.3mm, SD=17.5, N=66; median=14.3mm; Fig. 2). A significant difference occurs between the size distributions of recovered whole and rat preyed on shells (Chi square, $P < 0.001$).

3.1.3 *P. a. watti* (Whiriwhiri Stream) Again, most rat predation occurred in larger size classes (Fig. 3; median size class = 31-45mm) compared to natural (whole shell) mortality (Fig. 3). However, only 14 whole shells were found.

3.1.4 *P. a. michiei* (Surville Cliffs)
As noted previously, this is the only colony where rats appear to be absent (Table 4). The only predator(s) known to consume *P. a. michiei* today are thrushes and/or blackbirds. We have only seen and heard blackbirds in the area. The median size range of shells taken by blackbirds was 31-45mm (Fig. 4) -the most poorly represented among whole shell data (Fig. 4). The average size of whole shells was 46.2mm (SD=21.1, n=121; median 58.4). The size distributions of whole blackbird preyed on shells are significantly different comparing midpoint categories only (Chi-square, $P < 0.001$).

3.1.5 *Placostylus hongii*
The difference in size frequency distributions between whole shells and rat preyed on shells is not so marked for this species as it is for subspecies (Fig. 5). However, the distributions are significantly different (first four categories only, Chi-square, $P < 0.001$) indicating that rats are taking more snails in the 31-45mm and 46-60mm size classes than "natural" mortality factors. These cells in the contingency tables had two of the three highest contributions to the value of Chi-square, 2 of the 3 greatest departures from equality between the two distributions.

Table 1: Mortality of *P. a. michiei* on 2m x 2m quadrats, Surville Cliffs, Te Paki Farm Park

Quad	Rat eaten		Bird eaten		Whole shells			Total	
	Ad.	SA+J	Ad.	SA+J	Ad.	SA	J	Ad.	SA+J
1	0	0	0	0	0	0	1	0	1
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	8	0	8
4	0	0	0	0	1	0	4	1	4
5	0	0	0	0	0	1	1	0	2
6	0	0	0	0	0	0	3	0	3
7	0	0	0	0	0	1	9	0	10
8	0	0	0	0	0	1	2	0	3
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	10	0	10
11	0	0	0	0	0	0	1	0	1
12	0	0	0	0	1	1	5	1	6
Subtotal	0	0	0	0	2	4	44	2	48
Total	0		0		50(100%)			50	

Note:
(1) Mortality due to birds (*Turdus merula* and *T. turdus*) is underestimated in these samples because no 'anvils' were found in the quadrats. Two anvils were found nearby -the first contained 5 sub-adults and 1 juvenile and the second 11 juveniles. Five other anvils contained 4, 11, 13, 13 and 14 shells.
(2) Apparently rats caused no loss to snails, probably because they are absent.

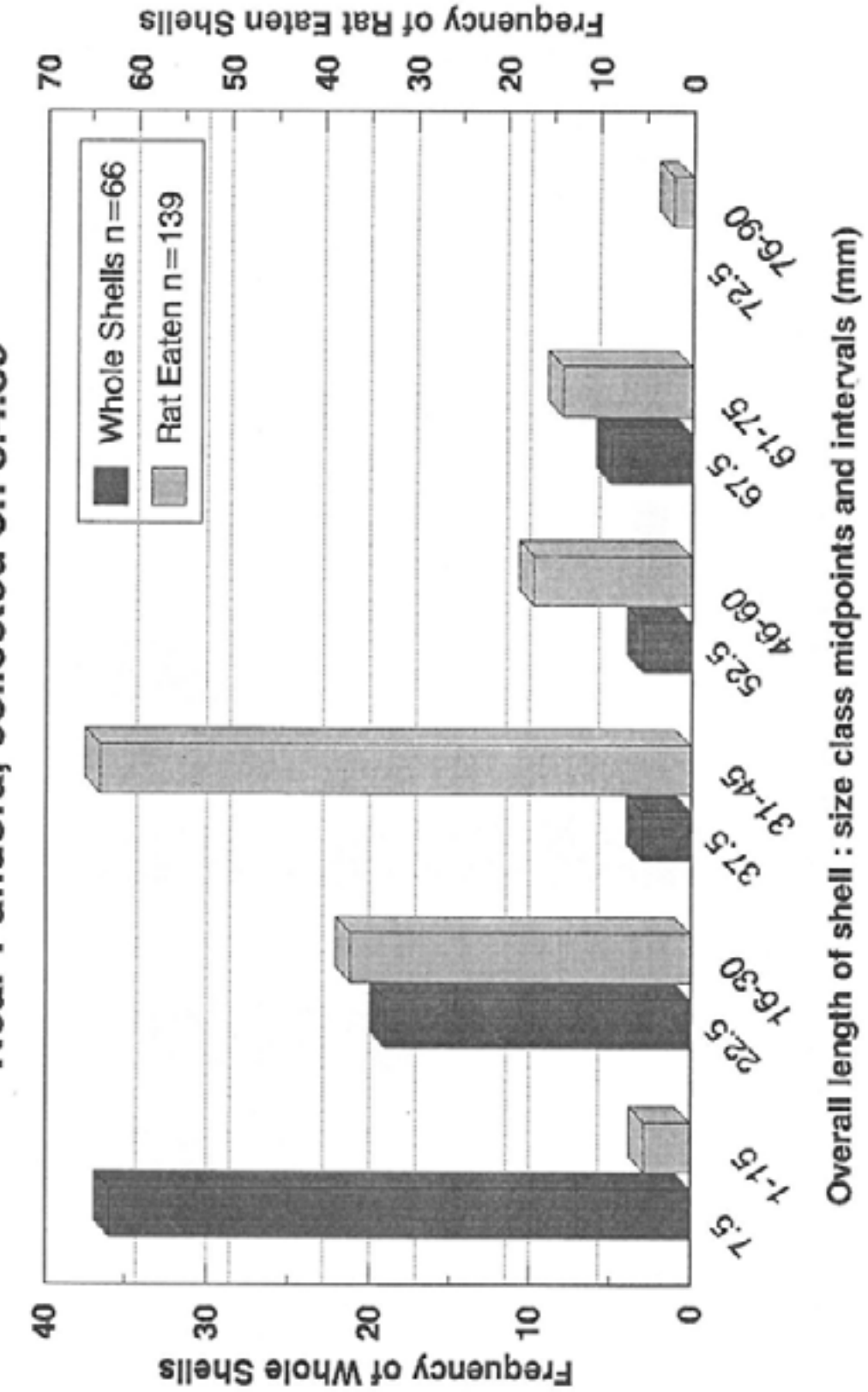


Fig. 2. Whole and Rat Eaten shells of *Placostylus ambagiosus new subspecies* Near Pandora, collected on 8.4.89

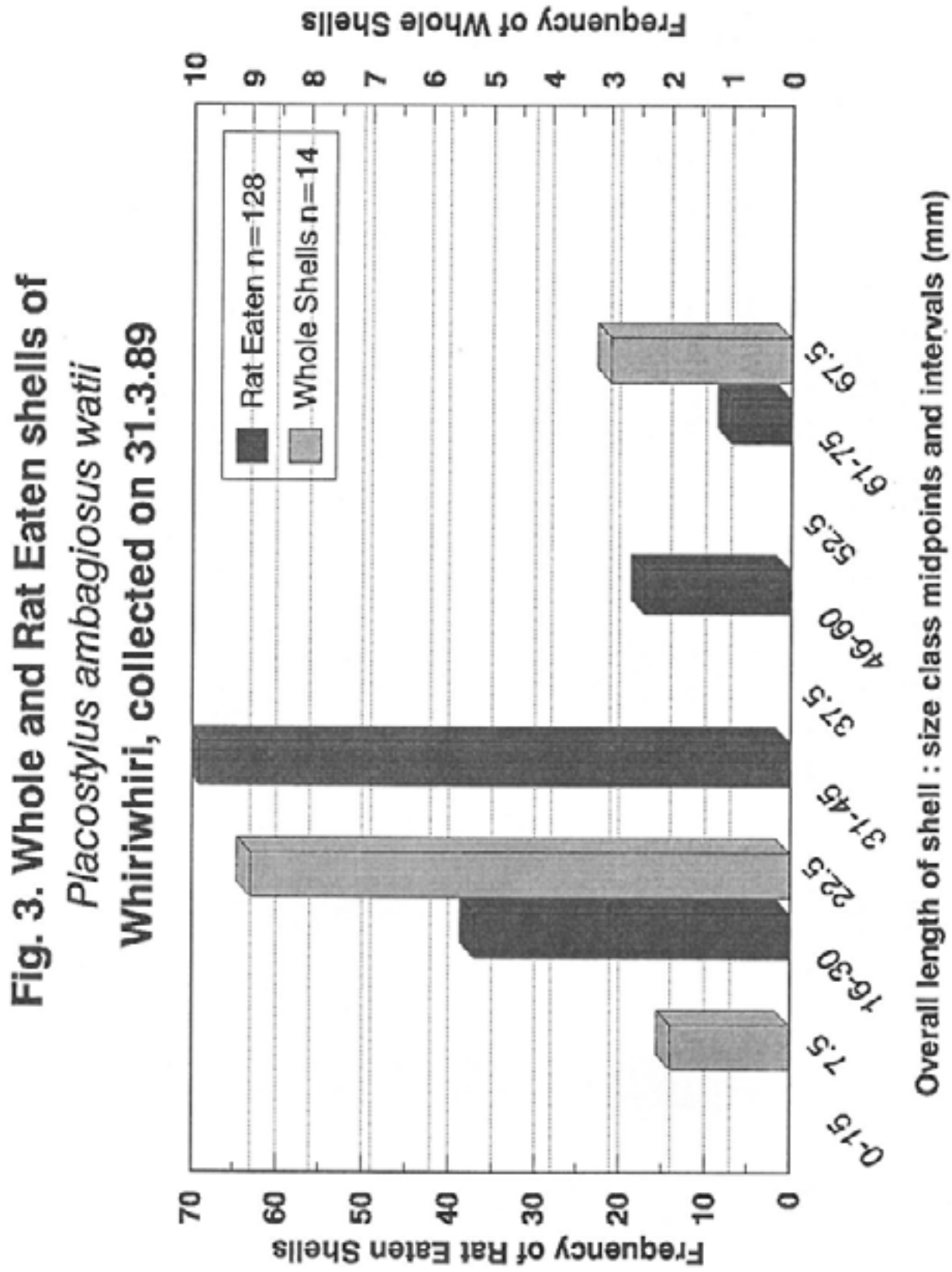


Fig. 3. Whole and Rat Eaten shells of *Placostylus ambagiosus watii* Whiriwhiri, collected on 31.3.89

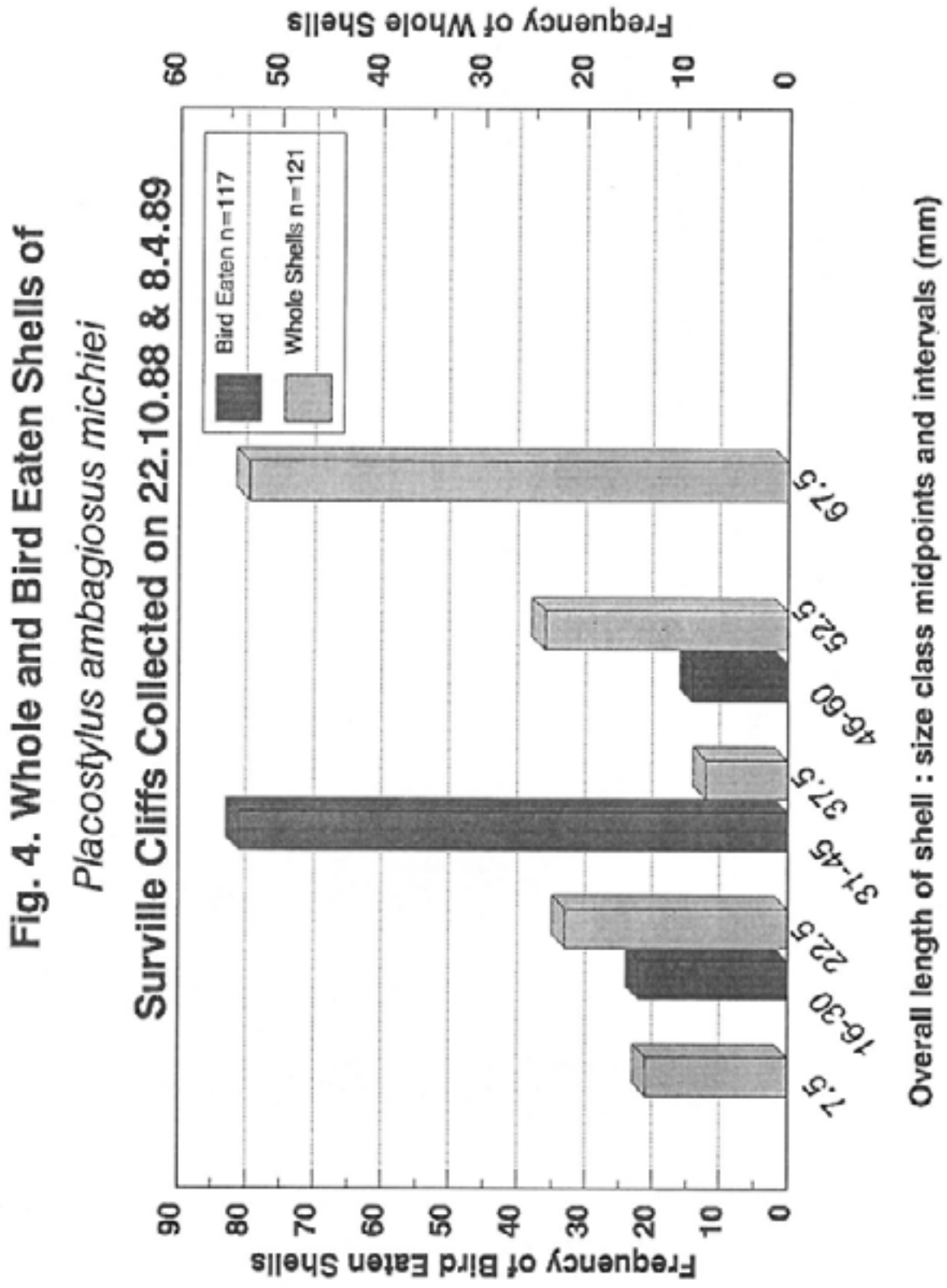


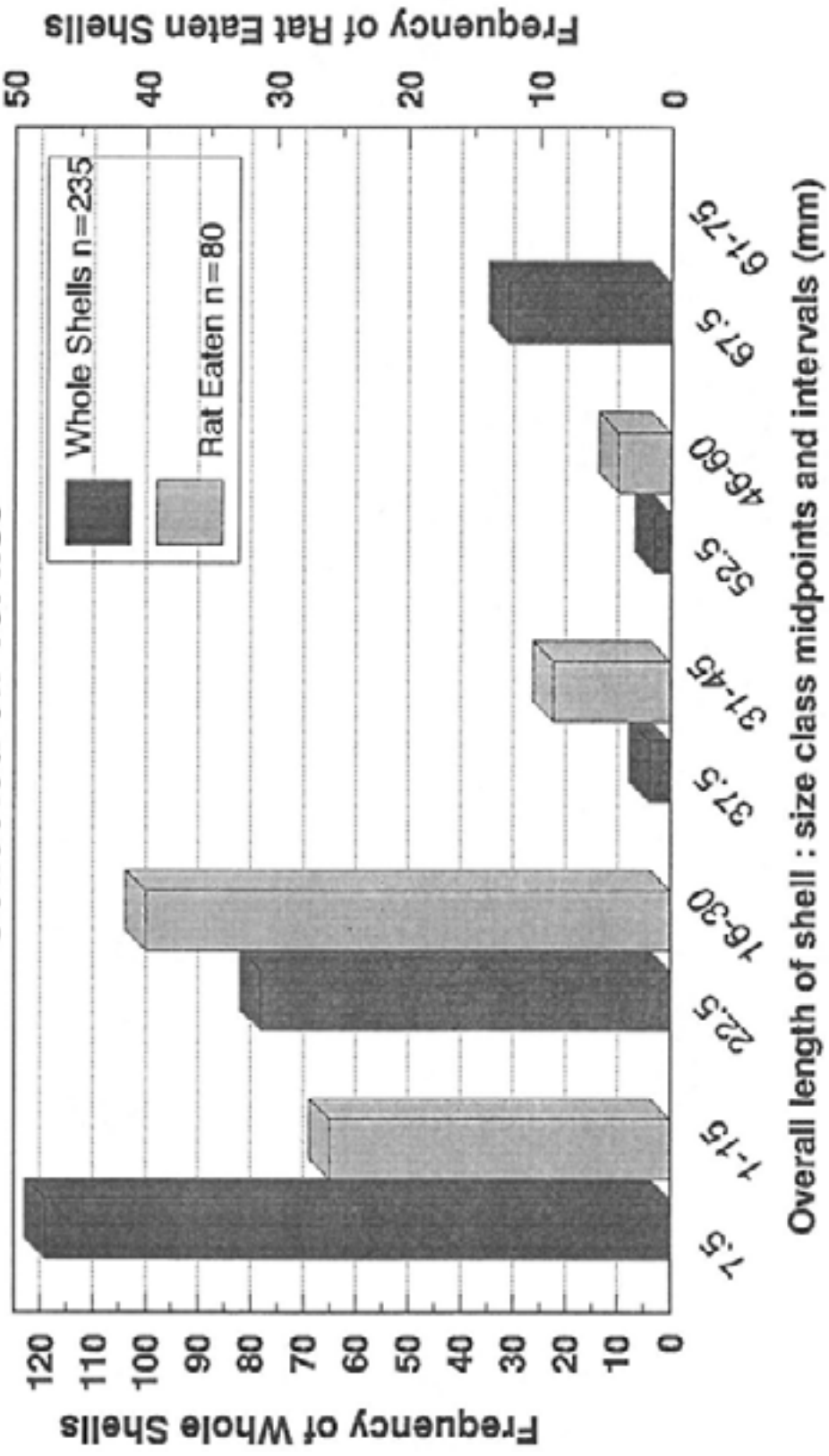
Fig. 4. Whole and Bird Eaten Shells of
Placostylus ambagiosus michiei
Surville Cliffs Collected on 22.10.88 & 8.4.89
Bird Eaten n=117
Whole Shells n=121
Frequency of Bird Eaten Shells
Frequency of Whole Shells
0
10
20
30
40
50
60
70
80
90
7.5
16-30
22.5
31-45
37.5
46-60
52.5
67.5
Overall length of shell : size class midpoints and intervals (mm)

Fig. 5. Whole and Rat Eaten Shells of

Placostylus hongii

Whangaruru North Head Scenic Reserve

Collected on 10.4.89



3.1.6 Comparison of size distributions of *P. a. michiei* and *P. a. paraspiritus.*

Comparison of the size distributions of whole shells of *P. a. michiei* and *P. a. paraspiritus* (Fig. 6) suggests mortality is higher in the smaller size categories of *P. a. paraspiritus* than of *P. a. michiei.* The distributions are significantly different (Chi-square, P, 0.001) with the cells contributing most to the Chi-square statistic being those either side of the middle size range. Specifcally *P. a. paraspiritus* suffered proportionately higher mortality in the first two size categories and *P. a. michiei* experienced higher mortality in the last two categories. Further confirmation of this trend is revealed by comparing the proportions of adult and sub-adults in live samples of (P.*a. paraspiritus)* (Table 2) with that of *P. a. michiei* (Table 4): relatively more adult and *P. a. michiei* were found.

Despite the fact that blackbirds confound the comparison (although the number of *P. a. michiei* they take is small), these results support the contention that rats selectively prey on small to middle-sized snails and thus they limit recruitment.

Table 4 Live *Placostylus ambagiosus michiei in 2m x 2m gradrats at Surville Cliffs, Te Paki Farm park.*

Quad	Adult	Sub-adult	Juvenile	Total
1	31	15	8	54
2	23*	5	6	34
3	11	1	9	21
4	19	1	1	21
5	11	0	1	12
6	15	4	3	22
7	11	2	2	15
8	12	4	0	16
9	13	6	2	21
10	14	7	8	29
11	3	0	0	3
12	25	5	1	31
Total	197 (67%)	54 (18%)	41 (15%)	292

* Recaptures of marked snails (from a previous study – unknown researcher) 62-62, 57-57, 58-58.

3.2 Rat and other predator trapping

The results of rat and hedgehog trapping at each colony are presented in Appendix 3. That 6 rats per 30 corrected trap nights (CTN) were caught at Maungapika before rat poisoning compared with zero one month later, suggests that poisoning is successful at removing rodents from colonies. While there was no trapping before poisoning on Pandora and CMVD east and west, there were no rats caught after poisoning at these locations either. That one hedgehog was caught at Pandora suggests that these could also be responsible for some predation.

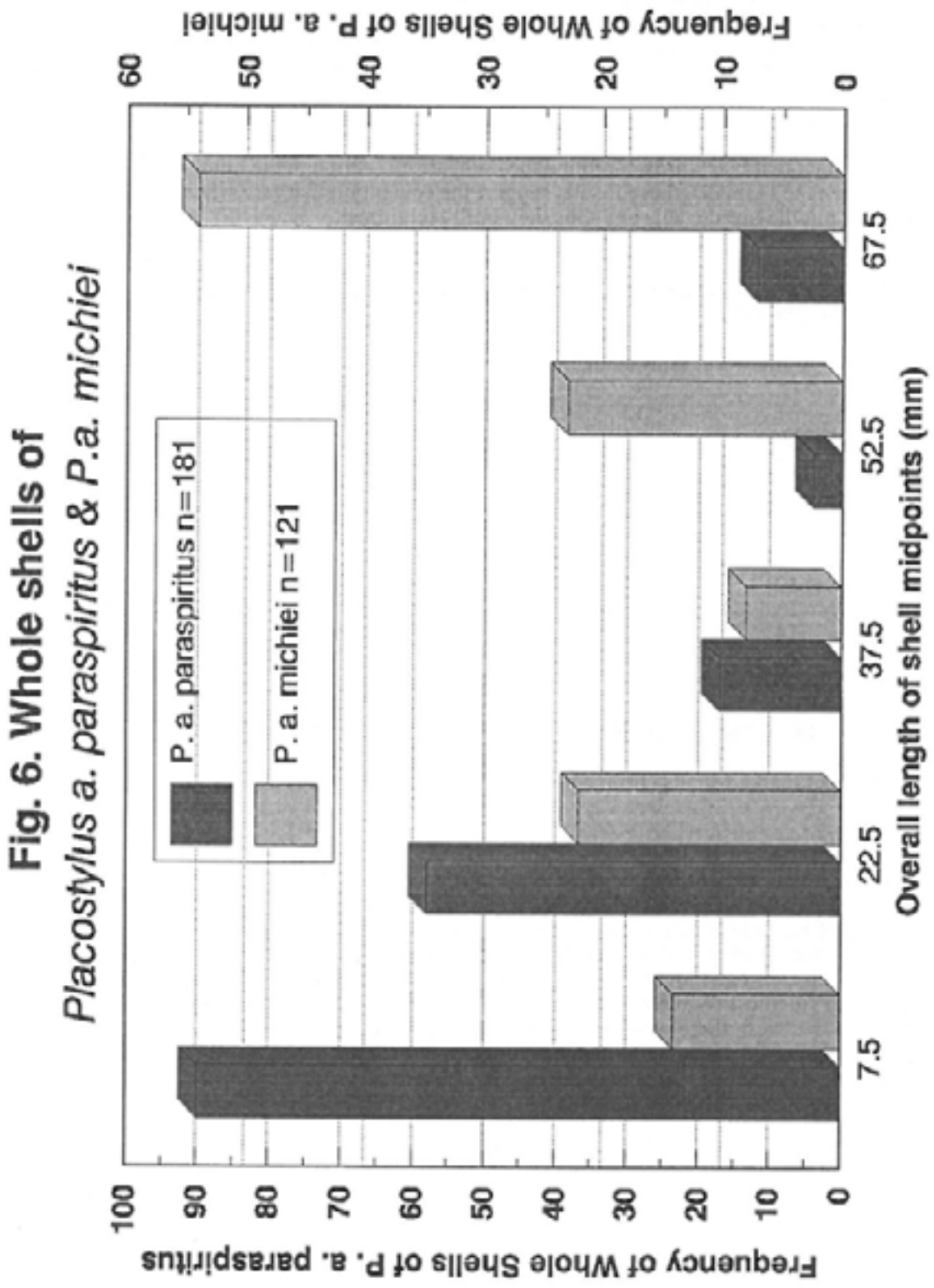


Fig. 6. Whole shells of
Placostylus a. paraspiritus & P.a. michiei
P. a. paraspiritus n=181
P. a. michiei n=121
Frequency of Whole Shells of P. a. paraspiritus
Frequency of Whole Shells of P. a. michiei
Overall length of shell midpoints (mm)
7.5
22.5
37.5
52.5
67.5
0
10
20
30
40
50
60
70
80
90
100

4. DISCUSSION

Penniket in a letter to the Wildlife Service stated that mice were responsible for snail predation at CMVD east. While our information does not reveal the culprit, we maintain that poisoning is working on mice as well if they are in fact there (see bait removal data Appendix 2). Hedgehogs have been seen at CMVD east (Don pers. and these may also be important predators of *P. a. paraspiritus*.

We do not believe that blackbirds at Surville Cliffs are responsible for the death of large numbers of snails. Most of the shells collected from anvils were very old. It is possible that the observations of previous workers of numerous snails being killed this way was the product of one or a few individual birds with a particular "search image" for snails.

The field experiment in this study has only just been set up. The other "half' of the experiment (with respect to data collection) is collecting data from CMVD east and Surville Cliffs (the "control") after two years of poisoning at the former and then again two years later after a new poisoning regime. Nor has research begun into the effects of exclosures and snail habitat enhancement on rat populations. Other necessary research should be a biochemical genetic study on sub-species differentiation (see section 2.17), since this will have a influence on where to direct management effort.

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APPENDIX 1

A. Mortality of *Helis aspersa* on 2m x 2m quadrats at CMVD West (location of *P. a. paraspiritus*), Te Paki Farm Park.

Quad	Rat eaten	Bird eaten	Whole shells	Total
1	9	0	2	11
2	7	0	0	7
3	8	0	0	8
4	45	0	0	45
5	34	0	13	47
6	39	0	19	56
7	6	0	0	6
8	46	0	5	51
9	20	0	28	48
10	42	0	19	61
11	10	0	8	18
12	2	0	1	3
Totals	268 (74%)	0	93 (26%)	361

Note: 67% of *H. aspersa* mortality was caused by rat predation.

B. Mortality of *Helis aspersa* on 2m x 2m quadrats at Surville Cliffs (location of *P. a. paraspiritus*), Te Paki Farm Park.

Quad	Rat eaten	Bird eaten	Whole shells	Total
1-12	0	0	0	0

APPENDIX 2

Poison bait take from *Placostylus ambagiosus* colonies in the Far North (data supplied by Don McKenzie)

Subspecies	# stations	Interval *	Orig # baits	Baits gone	%
Consobrinus	25	12	150	77	47
(CMVD West)	25	39	150	122	81
	19	120	150	150	100
Paraspiritus	30	9	180	60	33
(CMVD east)	30	12	174	47	27
	20	38	120	90	75
	11	120	114	114	100
Pandora	20	11	120	54	31
(Pandora Beach)	20	21	120	46	31
	20	120	120	120	100
Keenorum	27	10	162	144	89
(Maungapika)	27	67	162	74	46

* = days

Notes: - interval refers to the period since last rebaiting of stations.
- only whole baits were scored as taken. Partly chewed baits were counted as remaining.
- the black nova coil pipe may have resulted in a number of baits melting -they are made up in a wax medium
- invertebrates appeared to consume large amounts of poison as evidenced by droppings in the stations. Suspects include grasshoppers.
- one half bait present was scored as 1 present, less than half was scored as bait removed.

APPENDIX 3

Results of trapping for rats and other introduced snail predators in the Far North on 30.3.89, 9.4.89 and 29.6.89

Colony	Date	Traps set	Traps sprung		CTN1	Rats caught	Stoats caught	H/hogs	Traps fur
			1	2					
Pandora	3.4	60(R)	5	0	57.5	0	-	-	0
	"	19(F)	2	0	18	0	0	1[2]	0[3]
Mgpika W	4.[4]	60(R)[4]	16		50	4	-	-	3
	"	20(F)	1	0	48.5	2	1[5]	0	0
	29.6	20(F)	2[6]	0	20	0	0	0	0
Mgpika E	"	20(F)	2[6]	0	19	0	0	0	0
CMVD E	6.4	60(R)	0	0	60	0	-	-	0
	"	20(F)	1[6]	0	20	0	0	0	0
CMVD W	7.4	60(R)	1	0	59.5	0	-	-	0
	"	20(F)	0	0	20	0	0	0	0

R = rat traps, F = fenn traps

Key to superscripts:
1 - corrected trap nights = traps set minus traps sprung divided by half.
2 - no snail remains were found in the hedgehog's stomach.
3 - one feral cat was trapped and killed.
4 - one mouse was caught - recorded here as one trap sprung only.
5 - the stoat stomach contained remains of a skink
6 - harrier hawks were caught and killed.

Note: (1) weather conditions were the same for all nights trapped : fine and mild.
(2) where no rats were caught, there was no other sign of their presence e.g. droppings, chewing of baits.
(3) the subspecies *Rattus rattus frugivorus, R. r. rattus* and *R. r. alexandrinus* were caught at Maungapika West.