Mudfish (*Neochanna* Galaxiidae) literature review

Leanne K. O'Brien and Nicholas R. Dunn

SCIENCE FOR CONSERVATION 277

Published by
Science & Technical Publishing
Department of Conservation
PO Box 10420, The Terrace
Wellington 6143, New Zealand

Cover: *Neochanna apoda*, brown mudfish.
Photo: Stephen Moore.

Science for Conservation is a scientific monograph series presenting research funded by New Zealand Department of Conservation (DOC). Manuscripts are internally and externally peer-reviewed; resulting publications are considered part of the formal international scientific literature.
Individual copies are printed, and are also available from the departmental website in pdf form. Titles are listed in our catalogue on the website, refer www.doc.govt.nz under *Publications*, then *Science & technical*.

ISSN 1173-2946
ISBN 978-0-478-14264-8 (hard copy)
ISBN 978-0-478-14265-5 (Web PDF)

This report was prepared for publication by Science & Technical Publishing; editing by Ian Mackenzie and Lynette Clelland, and layout by Lynette Clelland. Publication was approved by the Chief Scientist (Research, Development & Improvement Division), Department of Conservation, Wellington, New Zealand.

In the interest of forest conservation, we support paperless electronic publishing. When printing, recycled paper is used wherever possible.

CONTENTS

Mudfish (*Neochanna* Galaxiidae) literature review

Leanne K. O'Brien and Nicholas R. Dunn

Ichthyo-niche, 26 Main South Road, Concord, Dunedin 9018, New Zealand
I_niche@xtra.co.nz

ABSTRACT

Neochanna (commonly called mudfish) are small, cryptic fish of the Galaxiidae family that exhibit extraordinary survival ability and amphibious behaviour. Of the six species of *Neochanna*, five are endemic to New Zealand. *Neochanna* species show a continuum of morphological transformation from *Galaxias*-like characteristics towards an anguilliform, or eel-like body plan. This literature review examines the extent to which this transformation series may provide a framework for understanding a range of characteristics of the genus. *Neochanna* species are wetland specialists and it is likely that they were abundant in the extensive wetlands that once covered much of New Zealand. Large tracts of these lowland areas have been drained and are now productive agricultural land. Remaining fragmented *Neochanna* populations face increasing challenges as their habitat continues to change. *Neochanna* species are adaptable, however, and are tolerant of disturbance and adverse conditions, to an extent. With increased public awareness and understanding, and habitat protection, there is every chance that these unique fish will persist. Overall, the taxonomic distinctiveness, general biogeography, and genetic structure of the genus *Neochanna* is fairly well known, but many aspects of the species' physiology, biology and ecological situation require further study.

Keywords: Galaxiidae, *Neochanna*, *Neochanna apoda*, *Neochanna burrowsius*, *Neochanna cleaveri*, *Neochanna diversus*, *Neochanna heleios*, *Neochanna rekohua*, mudfish, literature review, conservation, wetlands, New Zealand

O'Brien, L.K.; Dunn, N.R. 2007: Mudfish (*Neochanna* Galaxiidae) literature review. *Science for Conservation 277*. Department of Conservation, Wellington. 88 p.

1. Introduction

The ability of *Neochanna* (mudfish) species to survive periods without free surface water has long been recognised (Günther 1867; Roberts 1872). It is apparent that their amphibious nature and considerable tolerance to adverse conditions has enabled them to persist within an increasingly altered landscape. The majority of *Neochanna* populations occur in productive low-lying areas influenced by agricultural activities. This situation is unlikely to change substantially and there is a need to develop environmentally and economically sustainable solutions that address the apparent conflict between the persistence of *Neochanna* populations and intensive land and water management. Thus, advocacy and mutual co-operation between a wide range of landowners, government agencies, and contractors will be required to achieve conservation goals necessary to protect *Neochanna* populations. Importantly, the ability to address and communicate relevant issues with confidence requires a sound knowledge base.

This report reviews literature on the six currently recognised *Neochanna* species, highlighting aspects that may be important in directing future research, conservation and management initiatives. While the central focus of this review is the five *Neochanna* species that occurr in New Zealand, comparisons with the Australian *N. cleaveri* (Tasmanian mudfish) are made, to emphasise generalities within the genus. Each chapter has an introduction followed by sections covering specific topics, and is concluded, in most cases, with a summary of key chapter points. The last chapter, entitled 'information gaps', provides a summary of issues that require further study and understanding. A bibliography provides literature that relates to *Neochanna* species, in addition to references cited in the text. This review presents detailed information to make accessible information that can be difficult to obtain. To explore general patterns we have utilised several review methods including general meta-analysis approaches, conversion of results into common metrics, re-analysis and categorisation of raw data, data extraction programs to enumerate graphical information, and basic statistical analysis, where appropriate. Information from the New Zealand Freshwater Fish Database (NZFFD; McDowall & Richardson 1983) extracted on 30 July 2004 has also been used. Locations (Table 1) mentioned in the text are illustrated in Fig. 1.

1.1 CONSERVATION STATUS

The decline of *Neochanna* species since the arrival of humans is considered to be linked to the extensive reduction of their wetland habitats (McDowall 1982, 1998a; Swales 1991). Land development activities such as the removal of vegetation and the draining of wetlands have removed large areas of *Neochanna* habitat. In addition, habitat removal has been accompanied by channelisation to increase water flow and the introduction of exotic fish species. These have reduced the suitability for *Neochanna* of much of the remaining habitat (Skrzynski 1968; Eldon 1979a; Ling 2004). The impact of wetland drainage on *Neochanna* populations has been recognised since the late 1800s. A report by Roberts (1872: 456) quoted S.E. Vollams describing the decline of *N. apoda* (brown mudfish) in the Hokitika area: 'they are found in great numbers in making new roads through swampy land, but seem to disappear from the land on its being drained and cultivated'. Habitat drainage continues despite the historic destruction of approximately 90% of New Zealand's wetlands, and is a major and ongoing threat to *Neochanna* populations (Eldon 1978a; Swales 1991; Close 1996; DOC 2003).

Much of the evidence for a large-scale decline in *Neochanna* population abundance since people started modifying New Zealand's landscape is anecdotal (McDowall 1980a). However, there is evidence from genetic analyses that existing populations of *Neochanna* are remnants of larger populations (Gleeson 2000; Davey et al. 2003). Survey work has recorded instances of local extinction where *Neochanna* are now absent from areas where they were formerly present, e.g. Stokell (1945), Eldon (1993), Rebergen (1997), Francis (2000a). One example of this is the disappearance of *N. burrowsius* (Canterbury mudfish) populations that G.A. (Tony) Eldon studied extensively in the 1970s (Eldon et al. 1978; Eldon 1979a, b, c, 1993). On a more positive note, surveys continue to locate new populations, and have increased the confirmed distribution of several *Neochanna* species (Jellyman et al. 2003; DOC 2000b, 2004b); although such discoveries must be viewed in the context of continuing local extinctions, habitat loss, fragmentation and insufficient historic data (Eldon 1993; McGlynn & Booth 2002).

Despite the likelihood of ongoing local extinctions, not all species are in danger of complete extinction because of their presence in areas of protected wetland. For example, *N. diversus* (black mudfish) occurs in the extensive swamp areas of the Whangamarino Wetland and Kopuatai Peat Dome (Close 1996; Hicks & Barrier 1996); and *N. apoda* is present in the Koputaroa Scientific Reserve, near Levin, and Fensham Reserve in the Wairarapa (Richardson 1987; Rebergen 1997). However, species and populations that do not occur in such large, protected wetlands are extremely threatened. Emphasising this point is that many discoveries of *Neochanna* occur during drain clearance (Young 1996). The occurrence of *Neochanna* in waterways used or managed for agricultural purposes highlights the vulnerability of many remnant habitats. This is because growing pressure on water supplies for agricultural and other uses means that open agricultural drains are being viewed as less efficient than pipes for distributing water, and their closure and removal is being advocated (Morgan et al. 2002). There is widespread concern over the ability of *Neochanna* species to survive in an increasingly intensive agricultural landscape. As a result, all New Zealand *Neochanna* species have been classified as threatened under the Department of Conservation's (DOC's) threat of extinction classification system (Table 2; Hitchmough 2002; Molloy et al. 2002; Hitchmough et al. 2007). A recovery group has been formed and a 10-year recovery plan developed for the New Zealand *Neochanna* species (DOC 2003).

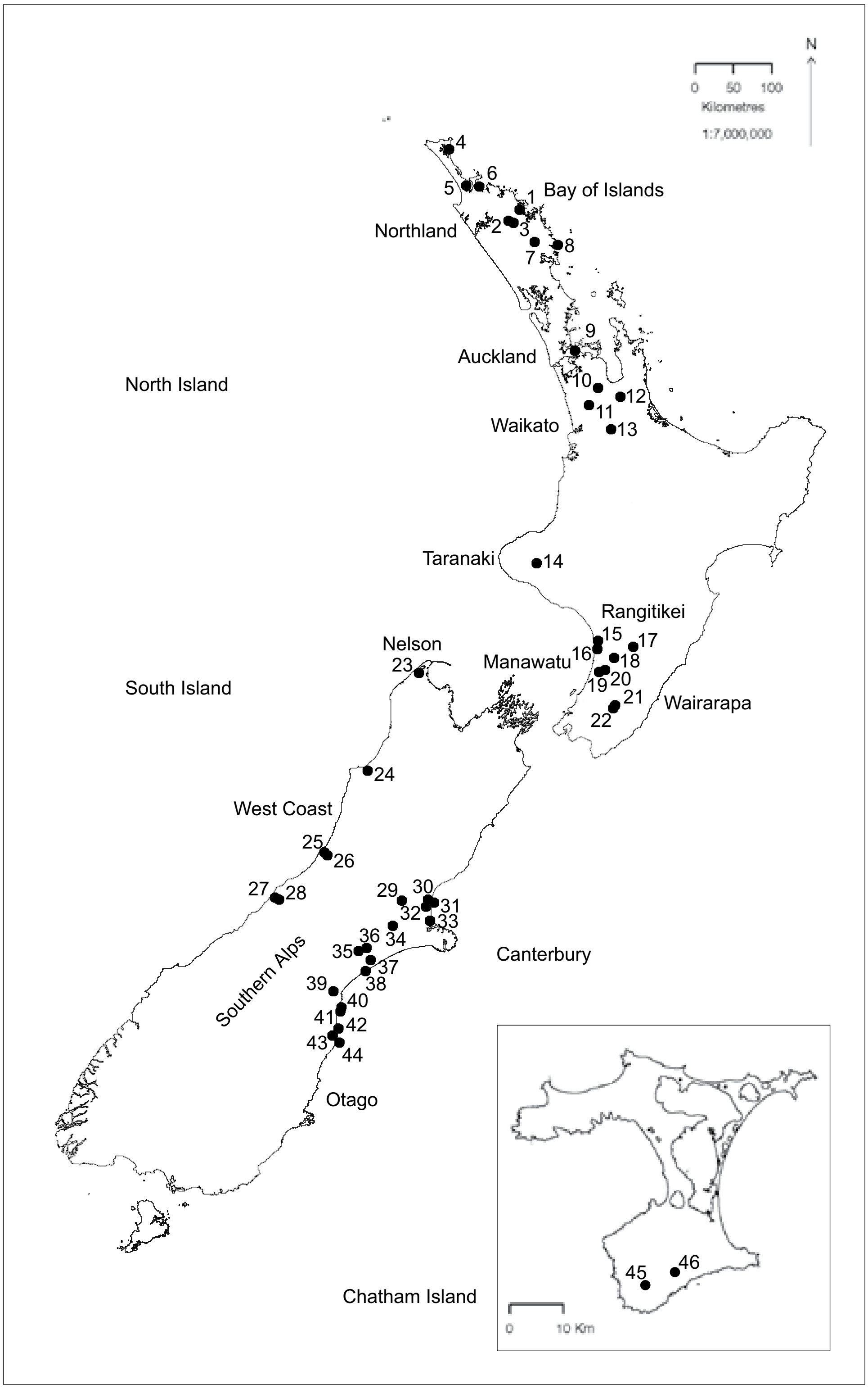
Over recent years, genetic studies and techniques have become useful tools in the conservation and management of threatened species. Genetic sequencing has been used to identify new species within *Neochanna* (Ling & Gleeson 2001), and to assign described species to the genus (Waters & White 1997). Of particular concern in the conservation of a species is genetic diversity. This issue is especially pertinent to *N. burrowsius*, which has low genetic diversity (Davey et al. 2003). Recognition of the unique genetic characteristics of populations and their importance for species conservation has led to the development of

TABLE 1. PLACE NAMES MENTIONED IN THE TEXT AND SHOWN IN FIG. 1, PLUS REGION AND *Neochanna* SPECIES PRESENT. NUMBERS ON MAP = LOCATION NUMBERS SHOWN IN FIG. 1.

MAP NUMBER	SPECIES	REGION	PLACE
1	*N. heleios*	Northland	Kerikeri
2			Lake Omapere
3			Ngawha
4	*N. diversus*	Northland	Parengarenga Harbour
5			Waiparera
6			Tokerau
7			Otakairangi
8			Ngunguru
9		Auckland	Newmarket
10		Waikato	Whangamarino Wetland
11			Awaroa Stream
12			Kopuatai Peat Dome
13			Holland Road drain
14	*N. apoda*	Taranaki	Stratford
15		Rangitikei	Santoft Forest
16			Rangitikei River
17		Manawatu	Ashhurst Domain
18			Manawatu River
19			Lake Horowhenua
20			Koputaroa Scientific Reserve
21		Wairarapa	Fensham Reserve
22			Hinau Valley
23		Nelson	Mangarakau
24		West Coast	German Terrace
25			Hokitika
26			Kaneiri
27			Okarito
28			The Forks
29	*N. burrowsius*	Canterbury	Oxford
30			Ashley River
31			Tutaepatu Lagoon
32			Ohoka
33			Christchurch botanical gardens
34			Hororata
35			Clearwell
36			Westerfield
37			Willowby
38			Lowcliffe
39			Taiko
40			St Andrews
41			Otaio
42			Buchanans Creek
43			Dog Kennel Stream
44		Otago	Waitaki River
45	*N. rekohua*	Chatham Island	Lake Rakeinui
46			Lake Tuku a Taupo

the concept of evolutionary significant units (ESUs). An ESU is a reproductively isolated group of populations displaying unique evolutionary characteristics (Ling et al. 2001). The degree of genetic distinctiveness identified will depend on the method of analysis used. Mitochondrial DNA (mtDNA) in the D-loop region has been used most commonly to define the ESUs of *Neochanna* species (e.g. Ling et al. 2001; Davey et al. 2003). To ensure preservation of equivalent genetic

Figure 1. Location (•) of *Neochanna* species habitats mentioned in the text. Numbers refer to place names as given in Table 1.



diversity it is recommended that the same method be used to define ESUs in all *Neochanna* species. The identification of ESUs (Fig. 2), indicates that protection of a few habitats for each *Neochanna* species may be insufficient to preserve their genetic heritage.

TABLE 2. THE SIX CURRENTLY RECOGNISED SPECIES OF *Neochanna*, ONE OF SIX GENERA IN THE FAMILY GALAXIIDAE. PLACEMENT OF AUTHORITIES WITHIN PARENTHESES INDICATES THAT A SPECIES WAS ORIGINALLY DESCRIBED IN ANOTHER GENUS BUT SUBSEQUENTLY SHIFTED TO *Neochanna*.

COMMON NAME	SCIENTIFIC NAME	AUTHORITY
Chatham Island mudfish*	*N. rekohua*	(Mitchell 1995)
Tasmanian mudfish	*N. cleaveri*	(Scott 1934)
Canterbury mudfish*	*N. burrowsius*	(Phillipps 1926)
Black mudfish†	*N. diversus*	Stokell 1949
Northland mudfish*	*N. heleios*	Ling & Gleeson 2001
Brown mudfish†	*N. apoda*	Günther 1867

* Acutely threatened species which is nationally endangered.
† Chronically threatened species in gradual decline.

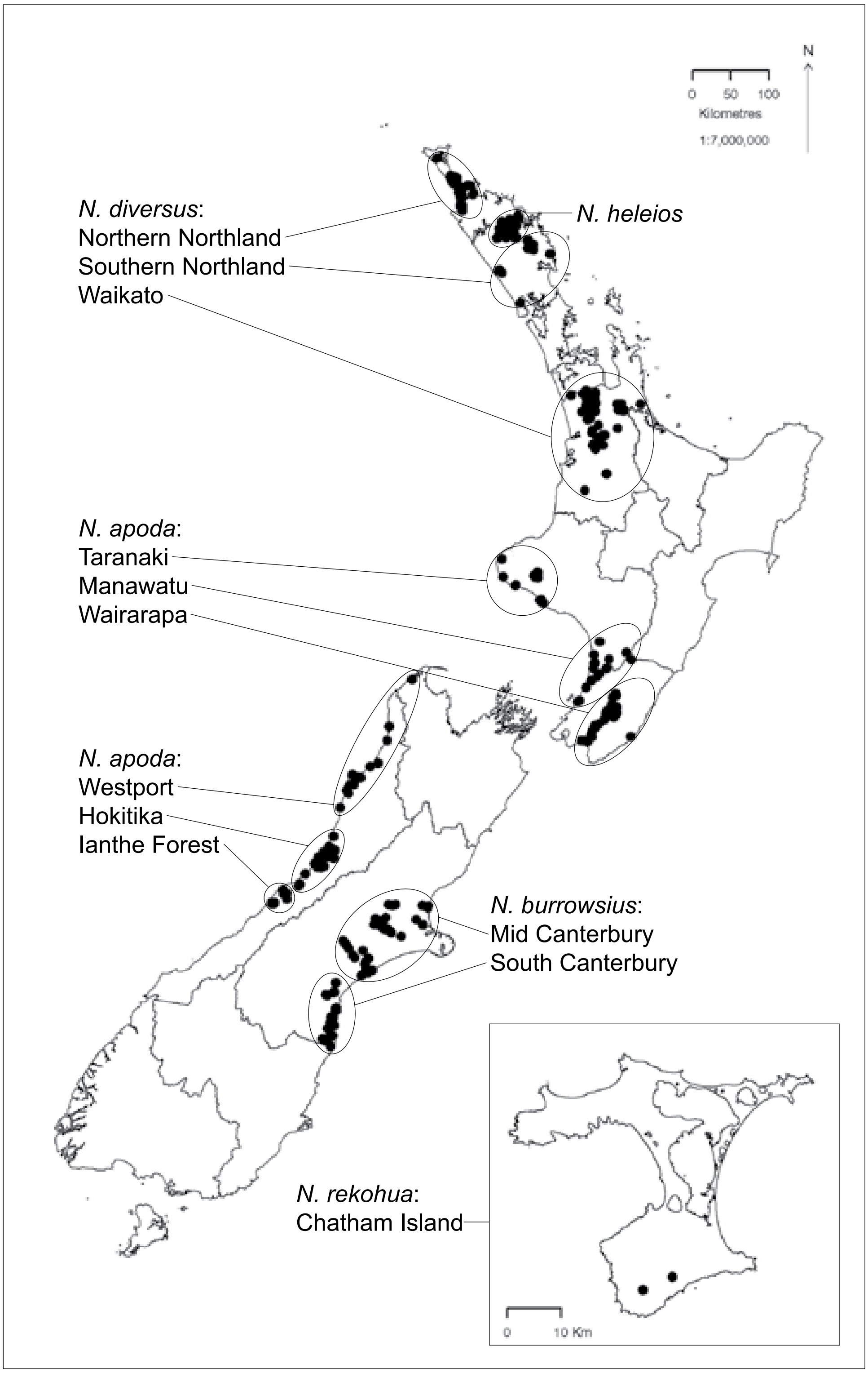
1.2 DESCRIPTION AND CHARACTERISTICS

Neochanna species belong to a group of southern hemisphere fishes known as galaxioids, which have an ancient evolutionary history (McDowall 2006). Within this group, phylogenetic studies show that *Neochanna* species are more closely related to Australian *Galaxiella* than to New Zealand *Galaxias* species (Waters et al. 2000). The general external characteristics of *Neochanna* species are a brown cigar-shaped, scale-less body, small eyes proportional to head size, large anterior nostrils, lateral pectoral fins, and a rounded caudal fin, akin to that of a stocky eel (Fig. 3; McDowall 1970, 1997a, 2000, 2004). *Neochanna* species have a distinctive swimming mode with 'high sinuosity' called anguilliform (eel-like) locomotion (McDowall 2003; Waters & McDowall 2005). This feature suggests an adaptation to habitats dominated by vegetation, and like *Anguilla* (Anguillidae, eel) species, an ability to live in crevices and holes, and possibly move over land (McDowall 1980b).

Based on morphological characteristics, McDowall (1997a, 2004) recognised that *Neochanna* species could be placed along a continuum indicating evolutionary transformation from a *Galaxias*-like to an anguilliform (eel-like) body plan (Fig. 3). Molecular phylogenetic analysis also strongly supports a single trajectory of progressive morphological specialisation during the radiation of *Neochanna* species in New Zealand (Waters & McDowall 2005). Two 'sister groups' can also be identified, comprising *N. burrowsius* and *N. rekohua*, and *N. apoda* and *N. heleios*, respectively (Fig. 3). This transformation series is interpreted as being the result of selection pressures acting on the genetic heritage of the genus, leading to increasing specialisation for existence in shallow wetlands (McDowall 2004; Waters & McDowall 2005).

Thus, externally, there is a trend towards the development of flanges along the caudal peduncle (anterior to the caudal (tail) fin), elongation of dorsal and anal fins, increasingly fleshy fins, and the reduction and loss of pelvic fins (Fig. 3; McDowall 1980b, 1997a, 2003, 2004). Development of small fleshy fins in *Neochanna* is likely to be a response to the need for fins that do not wear or tear easily when the fish move through complex semi-aquatic or terrestrial situations, such as wriggling through forest floor debris (McDowall 1980b, 2004). In the skeleton, changes include strengthening of the cranial region, fusing of

Figure 2. Distribution (•) of *Neochanna* species with evolutionary significant units (ESUs) for each species and DOC conservancy boundaries shown. ESUs based on mitochondrial DNA in the D-loop region. Distributional data from the New Zealand Freshwater Fish Database (as at 30 July 2004). Designation of ESUs from Gleeson et al. (1997, 1998, 1999), Gleeson (2000), Davey et al. (2003), and Gleeson & Ling (unpubl. data).



caudal bones, and the reduction and loss of the pelvic girdle (McDowall 1997a, 1999a, 2004). Distinctive trends relating to teeth morphology are also apparent, including the progressive loss of endopterygoid teeth. These teeth are present, albeit reduced, in *N. cleaveri*, *N. rekohua*, and *N. burrowsius*, occur less often and are small when present in *N. diversus*, but are always absent in *N. apoda* (McDowall 1997a, 2004). The jaw teeth of *N. heleios* and *N. apoda* also differ from those of all other *Neochanna* species in being flattened and incisor-like (McDowall 1980b, 1997a; Ling 1998; Ling & Gleeson 2001).

Continue to next file: sfc277a.pdf