



Pacific Horticultural and Agricultural Market Access Program (PHAMA)

Technical Report 26: Determination of the Quarantine Status of Nematodes on Fijian Taro Exports (FIJI04)

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Prepared for
AusAID

255 London Circuit
Canberra
ACT 2601
AUSTRALIA

4244103

URS

KALANG

Project Manager:



Sarah Nicolson

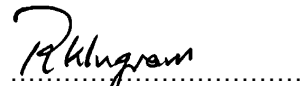
URS Australia Pty Ltd

**Level 4, 70 Light Square
Adelaide SA 5000
Australia**

T: 61 8 8366 1000

F: 61 8 8366 1001

Project Director:



Robert Ingram

Author:

Ruth Frampton
Short Term Advisor

Reviewer:



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Reference: 4244103

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.....
Rob Duthie
Principal Market Access Specialist

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Table of Contents

Executive Summary	iii
1 Introduction	1
1.1 Background	1
2 Nematodes Recorded in Fiji	3
2.1 Pest Surveys in Fiji	3
2.2 Current Relevant Research in Fiji	3
2.3 List of Nematodes Recorded on Taro, <i>Colocasia esculenta</i>, in Fiji.....	3
2.4 Quarantine Status in Australia and New Zealand of Nematodes Recorded in Fiji	5
2.5 Nematode Interceptions Recorded from Taro Exports to New Zealand	7
2.5.1 Types of Nematodes Intercepted	7
2.5.2 Pest Status of Nematodes Intercepted	8
3 Summary.....	12
4 Conclusions and Recommendations	21
5 References.....	23
6 Limitations	25

Tables

Table 2-1	Nematodes recorded on taro, <i>Colocasia esculenta</i> , in Fiji	3
Table 2-2	Status in Australia and New Zealand of nematodes recorded from taro in Fiji	6
Table 2-3	Types of nematodes intercepted in New Zealand on taro imported from Fiji during 2004–2005	8
Table 2-4	Biological status of nematodes recorded from taro in Fiji.....	9
Table 3-1	List of nematodes recorded on taro, <i>Colocasia esculenta</i> , in Fiji showing their quarantine status in New Zealand	12

Appendices

Appendix A List of Persons Consulted

Abbreviations

Abbreviation	Description
ACIAR	Australian Centre for International Agricultural Research
BORIC	Biosecurity Organisms Register for Imported Commodities
EU	European Union
FAO	The Food and Agriculture Organization of the United Nations
NZ MAF	New Zealand Ministry of Agriculture and Forestry
PHAMA	Pacific Horticultural and Agricultural Market Access Program
SPC	Secretariat of the Pacific Community
SPEC	South Pacific Bureau for Economic Cooperation
UNDP	United Nations Development Programme
URS	URS Australia Pty Ltd

Executive Summary

The main export markets for Pacific Island taro are New Zealand and Australia. The competitiveness of taro in these markets can be significantly affected by the quarantine requirements of the importing countries. In recent years, the main quarantine issue associated with Fiji taro exports to New Zealand is the presence of nematodes. Frequently during on-arrival inspections of taro consignments nematodes are discovered and as a result most consignments exported to New Zealand are fumigated. Fumigation adds to the exporters' cost structure, and decreases the shelf-life of the product.

To clarify whether fumigation is a technically justifiable response to the discovery by New Zealand inspectors of nematodes in fresh taro consignments from Fiji, the work documented in this report aimed to:

- Develop a comprehensive list of nematode species associated with Fiji taro corms;
- Develop, in conjunction with Biosecurity Authority Fiji and industry, a submission to the New Zealand Ministry of Agriculture and Forestry (NZ MAF) outlining the nematode species found on Fiji taro and their quarantine status in New Zealand; and
- If necessary, work with Biosecurity Authority Fiji to determine an operational policy to ensure that, if detected, only nematode species of quarantine concern require on-arrival quarantine measures.

Substantive works documenting the results of host/pest surveys in Fiji include Orton-Williams (1980), Kirby et al. (1980) and McKenzie et al. (2003; 2005). In isolation none of these works provides a comprehensive list of nematodes recorded on taro, *Colocasia esculenta*, in Fiji. For instance, in the survey of Fiji agricultural crops and commodities, McKenzie et al. (2005) collected only soil samples for extraction of nematodes, and acknowledged that the survey was not well suited for detecting the presence of stem and foliar nematodes belonging to the genera, *Aphelenchoides* and *Ditylenchus*. Collectively however, these works provide most of the documented and accessible records of nematodes recorded on taro, *Colocasia esculenta*, in Fiji.

Based on the records from the aforementioned host/pest surveys, a list of nematodes associated with taro has been compiled. The list includes nematodes of the genera *Aphelenchoides*, *Helicotylenchus*, *Meloidogyne*, *Pratylenchus*, and *Xiphinema*, as well as *Radopholus similis* and *Rotylenchulus reniformis*. Unfortunately, some of the nematodes collected during the surveys of Orton-Williams (1980), Kirby et al. (1980) and McKenzie et al. (2003; 2005) were identified (and recorded) to genus level only. For quarantine purposes, including pest risk analyses and market access submissions, it is preferable for organisms associated with a particular commodity to be listed to species level.

NZ MAF does not yet hold a specific list of regulated and non-regulated organisms associated with taro from Fiji as part of its import health standard for taro. However, from the Biosecurity Organisms Register for Imported Commodities (BORIC), a publicly accessible and searchable database, it is possible to obtain the quarantine status (i.e. whether an organism has been categorised as regulated or non-regulated) of many organisms. BORIC was accessed to obtain information on the quarantine status in New Zealand of nematode species included in the list of nematodes found in association with taro in Fiji.

All the nematodes fall, or potentially fall, into groups described as 'plant parasitic', and most (80%) of the 25 named nematode species are categorised by NZ MAF as 'regulated pests' for New Zealand.

There are no existing records of most (17 of the 20 species) of these “regulated” nematodes occurring in New Zealand.

The opportunity exists to obtain clarification of all the nematodes of potential concern likely to occur in Fiji’s taro export pathway. There are two Australian Centre for International Agricultural Research (ACIAR) projects – the *Cleaner Pathways* (PC/2007/118) and *Soil Health* (PC/2009/003) projects – that are now underway in Fiji and Samoa. Components of both projects involve soil and taro root sampling, extraction of nematodes from the samples and subsequent identification of the nematodes. Discussion with some Samoan researchers involved with the projects indicates that identifications undertaken will be to genus level only. It is understood that for some genera, morphological keys are available for subsequent species identification, but for others specimens could be prepared for molecular diagnosis and/or examination by experts to ensure species identifications are pursued. Advantage should be taken of this opportunity, particularly to clarify the species and feeding habits (as plant parasites or fungivores) of *Aphelenchoides* spp., given past interception records of nematodes on consignments of Fijian taro on-arrival in New Zealand. Examination of NZ MAF Border Interception Records for the period 1 January 2004 – 31 December 2005, the most recent and detailed New Zealand nematode interception dataset available, indicated that two genera, *Aphelenchoides* and *Aphelenchus*, made up a significant proportion of the identified interceptions (n=362; 79%) of nematodes on Fijian taro.

In conclusion, the following recommendations are made:

- *Arrange* for species-level identification (if appropriate from international experts), when technically possible, of those nematodes extracted from samples collected in the course of the ACIAR-funded *Cleaner Pathways* and *Soil Health* projects;
- Where possible, *coordinate* and/or *combine* soil and taro root sampling planned as part of the two ACIAR-funded projects in order to ensure adequate sample numbers from representative sites and valid comparative analyses of the results subsequently; and
- *Update* the list of nematodes associated with taro from Fiji (as presented in this report) as species information is clarified from current sampling; and
- *Request* NZ MAF (now the Ministry for Primary Industries) to review the quarantine status of nematodes in the genera *Aphelenchoides*, *Aphelenchus* and those ‘regulated’ ectoparasitic nematodes appearing on Fiji’s list of nematodes associated with taro (and provided in a Summary Table 3-1).

1 Introduction

1.1 Background

After sugar, taro is Fiji's largest agricultural export with an annual export volume over the last few years of around 10,000 tonnes (McGregor *et al.* 2011). About 65% of Fiji's taro exports go to New Zealand. McGregor *et al.* (2011) suggest that the main markets for Pacific Island taro are New Zealand and Australia, and that "the competitiveness of this taro in these markets is significantly reduced by:

- The quarantine protocols; and
- The production and marketing pathways that are currently in place."

In recent years, the main quarantine issue associated with Fiji taro exports to New Zealand is the presence of nematodes. Frequently during on-arrival inspections of taro consignments nematodes are discovered and as a result most consignments exported to New Zealand are fumigated. Fumigation adds to the exporters' cost structure, and decreases the shelf-life of the product.

Currently imports of fresh taro into New Zealand are conditional on any consignment being free of visually detectable quarantine pests, specified by the New Zealand Ministry of Agriculture and Forestry (NZ MAF) (www.biosecurity.govt.nz, accessed 21 February 2012). However, "there is no specific list of regulated¹ and non-regulated organisms associated with taro from Fiji in accordance with more recently issued country/commodity import health standards" (McGregor *et al.* 2011). These conditions have been in place for many years.

In November 2011, Biosecurity Australia issued *Biosecurity Australia Advice 2011/20* advising stakeholders of the release of the *Review of import conditions for fresh taro corms* final report. It noted that: "Quarantine requirements for the importation of fresh corms of taro varieties under the genus *Colocasia* from all countries, for the purpose of human consumption, have been in place for many years, requiring taro corms to be topped and free of all leaf material." During the review, six quarantine pests were identified as requiring additional quarantine measures to manage the risks to achieve Australia's appropriate level of protection. None of these were nematodes. Initiation of the Pest Risk Analysis had, however, identified 41 nematodes of taro across all countries that have the potential to be on fresh corms, four of which were categorised as quarantine pests for Australia and required pest risk assessment. Ultimately none of these nematodes were assessed as presenting a high enough risk to warrant additional quarantine measures.

To clarify whether fumigation is an appropriate response to the discovery by New Zealand inspectors of nematodes in fresh taro consignments from Fiji, the present study was undertaken to:

- Document nematode species associated with Fiji taro corms;
- Quantify the current level of taro consignments from Fiji treated for nematodes and the level of nematode identification conducted prior to treatment;
- Develop, in conjunction with Biosecurity Authority Fiji and industry, a submission to the New Zealand Ministry of Agriculture and Forestry outlining the nematode species found on Fiji taro and their quarantine status in New Zealand; and
- If necessary, work with Biosecurity Authority Fiji to determine an operational policy to ensure that, if detected only nematode species of quarantine concern require on-arrival quarantine measures.

¹ Regulated pests are those pests for which measures and actions would be undertaken if they were intercepted or detected (www.biosecurity.govt.nz, accessed 21 February 2011)

A list of those consulted in the preparation of this report is given in Appendix A.

2 Nematodes Recorded in Fiji

2.1 Pest Surveys in Fiji

Substantive works documenting the results of host/pest surveys in Fiji include Orton-Williams (1980), Kirby *et al.* (1980) and McKenzie *et al.* (2003; 2005). In isolation none of these works provides a comprehensive list of nematodes recorded on taro, *Colocasia esculenta*, in Fiji. For instance, in the survey of Fiji agricultural crops and commodities, McKenzie *et al.* (2005) collected only soil samples for extraction of nematodes, and acknowledged that the survey was not well suited for detecting the presence of stem and foliar nematodes belonging to the genera, *Aphelenchoides* and *Ditylenchus*. Collectively however, these works provide most of the documented and accessible records of nematodes recorded on taro, *Colocasia esculenta*, in Fiji (Table 2-1). More recent works, such as Khurma *et al.* (2008) and Singh (2009), provide greater resolution of the particular species involved.

2.2 Current Relevant Research in Fiji

As described in the Australian Centre for International Agricultural Research (ACIAR) publication, *Papua New Guinea and Pacific Nuis* (April 2011), two current ACIAR projects – the *Cleaner Pathways* (PC/2007/118) and *Soil Health* (PC/2009/003) projects – being undertaken in Fiji and Samoa include nematode research. Discussions with some of the Samoan project researchers, Angelika Matafeo (Plant Pathologist, Crop Division – Nu'u, Ministry of Agriculture and Fisheries) and Sanjay Anand (PhD Student, University of the South Pacific – Alafua), indicate that nematode identifications will be made under components of both ACIAR projects. At this stage, however, it appears it is the intention to identify representative nematodes extracted from soil, taro root and/or corm samples to genus level only. If the appropriate level of identification of nematodes extracted in the course of these ACIAR projects is pursued, additional details may enhance the value of the nematode list (Table 2-1) for market access purposes.

2.3 List of Nematodes Recorded on Taro, *Colocasia esculenta*, in Fiji

With reference to section 2.1, a list of nematodes recorded on taro, *Colocasia esculenta*, in Fiji has been compiled and is provided in Table 2-1.

Table 2-1 Nematodes recorded on taro, *Colocasia esculenta*, in Fiji

Species of Nematode	Order and Family	Reference(s)
<i>Aphelenchoides bicaudatus</i>	Aphelenchida: Aphelenchoididae	Orton-Williams 1980
<i>Aphelenchoides</i> spp.	Aphelenchida: Aphelenchoididae	Orton-Williams 1980
<i>Caloosia longicaudata</i>	Tylenchida: Caloosiidae	Orton-Williams 1980
<i>Criconemella denoudenii</i> (syn. <i>Macroposthonia denoudenii</i>)	Tylenchida: Criconematidae	Kirby <i>et al.</i> 1980 (as <i>Macroposthonia denoudenii</i>) Orton-Williams 1980 (as <i>Macroposthonia denoudenii</i>)
<i>Discocriconemella</i> sp.	Tylenchida: Criconematidae	Kirby <i>et al.</i> 1980 Orton-Williams 1980
<i>Ditylenchus</i> spp.	Tylenchida: Anguinidae	Orton-Williams 1980

Species of Nematode	Order and Family	Reference(s)
<i>Gracilacus aonli</i>	Tylenchida: Paratylenchidae	Orton-Williams 1985
<i>Gracilacus</i> sp.	Tylenchida: Paratylenchidae	Orton-Williams 1980
<i>Helicotylenchus crenacauda</i>	Tylenchida: Hoplolaimidae	Orton-Williams 1980
<i>Helicotylenchus dihystra</i>	Tylenchida: Hoplolaimidae	Kirby <i>et al.</i> 1980 Orton-Williams 1980
<i>Helicotylenchus erythrinae</i>	Tylenchida: Hoplolaimidae	Kirby <i>et al.</i> 1980
<i>Helicotylenchus indicus</i>	Tylenchida: Hoplolaimidae	Orton-Williams 1980
<i>Helicotylenchus microcephalus</i>	Tylenchida: Hoplolaimidae	Orton-Williams 1980
<i>Helicotylenchus mucronatus</i>	Tylenchida: Hoplolaimidae	Orton-Williams 1980
<i>Helicotylenchus multicinctus</i>	Tylenchida: Hoplolaimidae	Kirby <i>et al.</i> 1980 Orton-Williams 1980
<i>Helicotylenchus pseudorobustus</i>	Tylenchida: Hoplolaimidae	McKenzie <i>et al.</i> 2003 McKenzie <i>et al.</i> 2005
<i>Helicotylenchus</i> spp.	Tylenchida: Hoplolaimidae	Orton-Williams 1980 McKenzie <i>et al.</i> 2003 McKenzie <i>et al.</i> 2005 Unaisi Turaganivalu (pers. comm.)
<i>Hemicriconemoides cocophillus</i>	Tylenchida: Criconematidae	McKenzie <i>et al.</i> 2003 McKenzie <i>et al.</i> 2005
<i>Meloidogyne arenaria</i>	Tylenchida: Heteroderidae	Kirby <i>et al.</i> 1980 Orton-Williams 1980 Khurma <i>et al.</i> 2008 Singh 2009
<i>Meloidogyne incognita</i>	Tylenchida: Heteroderidae	Kirby <i>et al.</i> 1980 Orton-Williams 1980 Khurma <i>et al.</i> 2008 Singh 2009
<i>Meloidogyne javanica</i>	Tylenchida: Heteroderidae	Kirby <i>et al.</i> 1980 Orton-Williams 1980 McKenzie <i>et al.</i> 2003 McKenzie <i>et al.</i> 2005 Khurma <i>et al.</i> 2008 Singh 2009
<i>Meloidogyne</i> spp.	Tylenchida: Heteroderidae	Orton-Williams 1980 McKenzie <i>et al.</i> 2005 Unaisi Turaganivalu (pers. comm.)
<i>Mesocriconema onoensis</i> (syn. <i>Criconemella onoensis</i> , <i>Macroposthonia onoensis</i>)	Tylenchida: Criconematidae	Orton-Williams 1980 (as <i>Macroposthonia onoensis</i>) Kirby <i>et al.</i> 1980 (as <i>Macroposthonia denoudenii</i>) McKenzie <i>et al.</i> 2003 (as <i>Macroposthonia onoensis</i>) McKenzie <i>et al.</i> 2005 (as <i>Macroposthonia onoensis</i>) Secretariat of the Pacific Community (as <i>Criconemella onoensis</i>)
<i>Pratylenchus brachyurus</i>	Tylenchida: Pratylenchidae	Orton-Williams 1980

Species of Nematode	Order and Family	Reference(s)
<i>Pratylenchus coffeae</i>	Tylenchida: Pratylenchidae	Kirby <i>et al.</i> 1980 Orton-Williams 1980
<i>Pratylenchus zeae</i>	Tylenchida: Pratylenchidae	Orton-Williams 1980
<i>Pratylenchus</i> sp.	Tylenchida: Pratylenchidae	Orton-Williams 1980 McKenzie <i>et al.</i> 2003 McKenzie <i>et al.</i> 2005 Unaisi Turaganivalu (pers. comm.)
<i>Radopholus similis</i>	Tylenchida: Pratylenchidae	Kirby <i>et al.</i> 1980 Orton-Williams 1980
<i>Rotylenchulus reniformis</i>	Tylenchida: Hoplolaimidae	Kirby <i>et al.</i> 1980 Orton-Williams 1980 McKenzie <i>et al.</i> 2003 (Appendix 5) Unaisi Turaganivalu (pers. comm.)
<i>Xiphinema brevicolle</i>	Dorylaimida: Longidoridae	Kirby <i>et al.</i> 1980 Orton-Williams 1980
<i>Xiphinema ensiculiferum</i>	Dorylaimida: Longidoridae	Kirby <i>et al.</i> 1980 Orton-Williams 1980
<i>Xiphinema insigne</i>	Dorylaimida: Longidoridae	Orton-Williams 1980

2.4 Quarantine Status in Australia and New Zealand of Nematodes Recorded in Fiji

As mentioned above, NZ MAF does not yet hold a specific list of regulated and non-regulated organisms associated with taro from Fiji as part of its import health standard for taro. However, it does maintain what is referred to as the Biosecurity Organisms Register for Imported Commodities (BORIC). From BORIC, a publicly accessible and searchable database, it is possible to obtain the quarantine status (i.e. whether an organism has been categorised as regulated or non-regulated) of many organisms. Records in this database have been compiled from identifications to genus and species level of organisms intercepted on imported consignments, as well as data gathered in the preparation of pest lists for inclusion in New Zealand's country/commodity import health standards. BORIC was therefore accessed to obtain information on the quarantine status in New Zealand of nematode species found in association with taro in Fiji (Table 2-2). However, BORIC may not record the complete list of organisms for which New Zealand has specified their quarantine status over the past.

Reference to McLeod *et al.* (1994), together with information contained in the Review of import conditions for fresh taro corms released recently by Biosecurity Australia (Biosecurity Australia 2011), enabled similar information to be compiled for Australia (Table 2-2). Of the 25 named nematode species on the list of nematodes recorded from taro in Fiji, just two (namely, *Helicotylenchus microcephalus* and *H. mucronatus*) have been categorised by Biosecurity Australia as quarantine pests (Table 2-2). In contrast, 20 of the 25 named nematode species on the list of nematodes recorded from taro in Fiji have been categorised as regulated pests by NZ MAF. There are no existing records of most (17 of the 20 species) of these "regulated" nematodes occurring in New Zealand (Knight *et al.* 1997; Knight 2001; Mercer and Miller 1997).

Table 2-2 Status in Australia and New Zealand of nematodes recorded from taro in Fiji

Species of Nematode from Taro in Fiji	Present in Australia (McLeod <i>et al.</i> 1994)	Quarantine Status in New Zealand (MAF BORIC ²)
<i>Aphelenchoides bicaudatus</i>	Yes (N, Q, V, W)	Regulated
<i>Aphelenchoides</i> spp.	<i>Aphelenchoides besseyi</i> (NT, Q); <i>Aphelenchoides bicaudatus</i> (N, Q, V, WA)	–
<i>Caloosia longicaudata</i>	No record	Regulated
<i>Criconemella denoudenii</i>	No record	Regulated
<i>Discocriconemella</i> sp.	– ¹	–
<i>Ditylenchus</i> spp.	– ¹	–
<i>Gracilacus aonli</i>	No record	Regulated
<i>Gracilacus</i> sp.	– ¹	–
<i>Helicotylenchus crenacauda</i>	No record	Regulated
<i>Helicotylenchus dihystra</i>	Yes (N, NT, Q, S, V, W)	Non-regulated (Knight <i>et al.</i> 1997; Knight 2001)
<i>Helicotylenchus erythrinae</i>	Yes (Q, S)	Regulated (Knight <i>et al.</i> 1997)
<i>Helicotylenchus indicus</i>	No record	Regulated
<i>Helicotylenchus microcephalus</i>	No record; Quarantine (Biosecurity Australia 2011)	Regulated
<i>Helicotylenchus mucronatus</i>	No record; Quarantine (Biosecurity Australia 2011)	Regulated
<i>Helicotylenchus multicinctus</i>	Yes (N, NT, Q, S, W)	Regulated
<i>Helicotylenchus pseudorobustus</i>	Yes (V, W) ¹	Non-regulated (Knight <i>et al.</i> 1997; Knight 2001)
<i>Helicotylenchus</i> spp.	– ¹	–
<i>Hemicriconemoides cocophillus</i>	Yes (NT, Q, W)	Regulated
<i>Meloidogyne arenaria</i>	Yes (N, Q, S, T, V, W)	Regulated (as <i>M. thamesi</i>) (Knight <i>et al.</i> 1997)
<i>Meloidogyne incognita</i>	Yes (N, NT, Q, S, T, V, W)	Non-regulated (Knight <i>et al.</i> 1997; Mercer and Miller 1997)
<i>Meloidogyne javanica</i>	Yes (A, N, NT, Q, S, T, V, W)	Non-regulated (Knight <i>et al.</i> 1997; Mercer and Miller 1997)
<i>Meloidogyne</i> spp.	– ¹	–
<i>Mesocriconema onoensis</i> (syn. <i>Criconemella onoensis</i> , <i>Macroposthonia onoensis</i>)	Yes (NT [Sauer 1981])	Regulated (as <i>Criconemella onoensis</i>)
<i>Pratylenchus brachyurus</i>	Yes (N, NT, Q, W)	Regulated
<i>Pratylenchus coffeae</i>	Yes (N, Q, S, V, W)	Regulated (Knight <i>et al.</i> 1997)
<i>Pratylenchus zeae</i>	Yes (N, NT, Q, V)	Regulated
<i>Pratylenchus</i> sp.	– ¹	–

Species of Nematode from Taro in Fiji	Present in Australia (McLeod <i>et al.</i> 1994)	Quarantine Status in New Zealand (MAF BORIC ²)
<i>Radopholus similis</i>	Yes (N, NT, Q, S, W)	Regulated
<i>Rotylenchulus reniformis</i>	Yes (NT, W) [Sauer 1981]	Regulated
<i>Xiphinema brevicolle</i>	Yes (N, Q, V, W)	Non-regulated
<i>Xiphinema ensiculiferum</i>	Yes (N, Q)	Regulated
<i>Xiphinema insigne</i>	Yes (N, NT, Q, W)	Regulated

¹ Not listed in Biosecurity Australia (2011) although species belonging to this genus are present in Australia

² BORIC (MAF Biosecurity Organisms Register for Imported Commodities, updated 20 February 2012), accessed 21 February 2012

2.5 Nematode Interceptions Recorded from Taro Exports to New Zealand

At first glance then it would appear that the discovery by New Zealand inspectors of nematodes (most likely to be ‘regulated’ species) in fresh taro consignments from Fiji warrants treatment, in this case fumigation, of affected consignments before final clearance. However, in the absence of detailed pest risk assessments of the 20 species having been undertaken by NZ MAF, the opportunity is taken to examine more closely NZ MAF nematode interception records as well as compile relevant biological information on each species. Assessment of such records and/or information may assist in any discussions with NZ MAF on concerns raised about nematodes on taro from Fiji.

2.5.1 Types of Nematodes Intercepted

NZ MAF Border Interception Records for the period 1 January 2004 – 31 December 2005 had been previously obtained by the author for the purposes of another project. Permission was sought from, and granted by, Dr V. Herrera, NZ MAF (via emails of 12 and 13 September 2011), to use the subset of this large dataset (over 15,000 records) that related to interceptions from imported consignments of taro. Over 96% of the taro interceptions were from imports of taro from Fiji, and almost half of these involved the submission of samples to “Nematology” for identification – the resulting nematode identification records total 1,306. The identification of well over half of these nematode samples (n=849; 65%) could not be determined. A summary of the remaining 35% of identifications (n=457) is shown in Table 2-3. Notably, since 31 March 2006 identification of nematode interceptions from taro imports at New Zealand’s border have been rarely pursued – the records used in this analysis constitute the most detailed New Zealand nematode interception dataset available.

372 of the 457 identified nematodes (81.4%) are of species included in Table 2-1. Only two of the identified nematode interceptions were clearly non-regulated species – specifically *Helicotylenchus pseudorobustus* and *Meloidogyne incognita* – as categorised by NZ MAF. This represents 0.44% of the identified interceptions, and if unidentifiable ones are taken into account, just 0.15% of the nematode interceptions required no regulatory action.

Table 2-3 Types of nematodes intercepted in New Zealand on taro imported from Fiji during 2004–2005

Nematode Class and Order	Nematode Family	Nematode Species	Number
Adenophorea, Dorylaimida	Mononchidae	<i>Mylonchulus</i> sp.	1
Adenophorea, Dorylaimida	Undetermined	–	5
Secernentea, Aphelenchida	Aphelenchidae	<i>Aphelenchus</i> sp.	67
Secernentea, Aphelenchida	Aphelenchoididae	<i>Aphelenchoides</i> sp.	295
Secernentea, Rhabditida	Undetermined	–	2
Secernentea, Rhabditida	Cephalobidae	–	1
Secernentea, Tylenchida	Anguinidae	<i>Ditylenchus</i> sp.	3
Secernentea, Tylenchida	Heteroderidae	<i>Heterodera</i> sp. ¹	1
Secernentea, Tylenchida	Heteroderidae	<i>Meloidogyne incognita</i>	1
Secernentea, Tylenchida	Heteroderidae	<i>Meloidogyne</i> sp.	8
Secernentea, Tylenchida	Hoplolaimidae	<i>Helicotylenchus californicus</i> ²	2
Secernentea, Tylenchida	Hoplolaimidae	<i>Helicotylenchus egyptiensis</i> ³	2
Secernentea, Tylenchida	Hoplolaimidae	<i>Helicotylenchus microcephalus</i>	1
Secernentea, Tylenchida	Hoplolaimidae	<i>Helicotylenchus mucronatus</i>	1
Secernentea, Tylenchida	Hoplolaimidae	<i>Helicotylenchus pseudorobustus</i>	1
Secernentea, Tylenchida	Hoplolaimidae	<i>Helicotylenchus</i> sp.	18
Secernentea, Tylenchida	Hoplolaimidae	<i>Rotylenchulus reniformis</i>	3
Secernentea, Tylenchida	Pratylenchidae	<i>Pratylenchus coffeae</i>	37
Secernentea, Tylenchida	Pratylenchidae	<i>Pratylenchus</i> sp.	2
Secernentea, Tylenchida	Tylenchidae	<i>Tylenchus</i> sp.	3
Secernentea, Tylenchida	Tylenchulidae	<i>Gracilacus</i> sp.	3
Total			457

¹ Although not recorded on taro (refer Table 2-1), two species of *Heterodera*, *H. graminis* and *H. mothi* have been identified from Fiji (Orton-Williams, 1980)

² Recorded in association with three hosts in Fiji, *Bruguiera gymnorhiza* (dogo), *Pandanus* spp. (pandanus) and *Rhizophora mangle* (mangrove tree) (Orton-Williams, 1980) but not in taro (refer Table 2-1)

³ Orton-Williams (1980) recorded this species in association with one host and McKenzie *et al.* (2005) recorded it with nine hosts, but not with taro (refer Table 2-1)

2.5.2 Pest Status of Nematodes Intercepted

In examining the feeding habits of soil nematode families and genera, Yeates *et al.* (1993) proposed seven broad categories of nematodes for ecological purposes, two of which are particularly relevant to the present study:

1. Plant feeding (involving soil nematodes feeding on vascular plants)
 - a) Sedentary parasites (e.g. females of *Meloidogyne*, *Globodera*, *Sphaeronema*)
 - b) Migratory endoparasites (e.g. Pratylenchidae, some Anguinidae)
 - c) Semi-endoparasites (e.g. Hoplolaimidae, *Telotylenchus*)
 - d) Ectoparasites (e.g. Dolichodoridae, Criconematidae, Paratylenchidae, Longidoridae)
 - e) Epidermal cell and root hair feeders (e.g. Tylenchidae)
 - f) Algal or lichen feeders

2. Hyphal feeding.

From a crop production perspective, those nematodes of greatest concern tend to be referred to as “plant parasitic nematodes”. In a publication on plant parasitic nematodes of New Zealand, Knight *et al.* (1997) clarified their use of the term “plant-parasitic nematode” to mean nematodes in categories 1a–1d of Yeates *et al.* (1993).

Table 2-4 provides the list of nematodes found in association with taro in Fiji and the categories of Yeates *et al.* in which they fall. Notably, most of the nematode species listed in Table 2-4 (from Table 2-1, as well as *Aphelenchus* from Table 2-3) fall, or potentially fall, in the “plant-parasitic nematode” categories applied in New Zealand. However, these categories do not necessarily equate to the probability of the listed nematodes being on or in taro corms, the commodity being exported. Biosecurity Australia’s recent assessment of these nematodes for their “potential to be on corms” is, therefore, also provided in Table 2-4.

The species in **bold** text in Table 2-4 are those that NZ MAF classifies as non-regulated. Shaded rows in Table 2-4 highlight species that have been intercepted on Fijian taro exported to New Zealand. Given the feeding habits (as “plant-parasitic”), “potential to be on corms” and interception records of nematodes associated with taro in Fiji, NZ MAF’s ‘regulated pest’ categorisation of species of *Helicotylenchus*, *Pratylenchus* and *Radopholus* not already present in New Zealand appears appropriate at this time, as is the response to such nematode interceptions. However, the quarantine status of nematodes in the genera *Aphelenchoides*, *Aphelenchus* and *Ditylenchus* – hyphal, algal or lichen feeding nematodes – cannot be justified if applying the International Plant Protection Convention definition of ‘quarantine pest’ (as “a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled”). In addition, the ‘regulated’ status of ectoparasitic (Yeates *et al.* (1993) category 1d) nematodes is questionable.

Table 2-4 Biological status of nematodes recorded from taro in Fiji

Species of Nematode from Taro in Fiji	Common Name	Biological Status (Yeates <i>et al.</i> 1993)	Potential to be on taro corms (Appendix 1, Biosecurity Australia (2011))
<i>Aphelenchoides bicaudatus</i>	No common name	Hyphal feeding [2]	No
<i>Aphelenchoides spp.</i>	–	Hyphal feeding [2], 1b, 1e or 1f	No (based on <i>A. besseyi</i> and <i>A. bicaudatus</i>)
<i>Aphelenchus sp.</i>	–	Hyphal feeding [2], or 1f	No (based on <i>A. avenae</i>)
<i>Caloosia longicaudata</i>	Ring nematode	Ectoparasite [1d]	No
<i>Criconemella denoudenii</i>	Ring nematode	Ectoparasite [1d]	Yes
<i>Discocriconemella sp.</i>	–	Ectoparasite [1d]	–
<i>Ditylenchus spp.</i>	Stem and bulb nematodes	Hyphal feeding [2], or migratory endoparasites [1b] (mainly in shoots)	–
<i>Gracilacus aonli</i>	No common name	Ectoparasite [1d]	No
<i>Helicotylenchus crenacauda</i>	Spiral nematode	Semi-endoparasite ¹ [1c]	No

Species of Nematode from Taro in Fiji	Common Name	Biological Status (Yeates <i>et al.</i> 1993)	Potential to be on taro corms (Appendix 1, Biosecurity Australia (2011))
<i>Helicotylenchus dihystra</i>	Common spiral nematode	Semi-endoparasite ¹ [1c]	Yes
<i>Helicotylenchus erythrinae</i>	Spiral nematode	Semi-endoparasite ¹ [1c]	Yes
<i>Helicotylenchus indicus</i>	Spiral nematode	Semi-endoparasite ¹ [1c]	Yes
<i>Helicotylenchus microcephalus</i>	Spiral nematode	Semi-endoparasite ¹ [1c]	Yes
<i>Helicotylenchus mucronatus</i>	Spiral nematode	Semi-endoparasite ¹ [1c]	Yes
<i>Helicotylenchus multicinctus</i>	Banana spiral nematode	Semi-endoparasite ¹ [1c]	Yes
<i>Helicotylenchus pseudorobustus</i>	Spiral nematode	Semi-endoparasite ¹ [1c]	–
<i>Hemicriconemoides cocophillus</i>	No common name	Ectoparasite [1d]	No
<i>Meloidogyne arenaria</i>	Peanut root-knot nematode	Sedentary endoparasite [1a]	No
<i>Meloidogyne incognita</i>	Root-knot nematode	Sedentary endoparasite [1a]	No
<i>Meloidogyne javanica</i>	Sugarcane eelworm	Sedentary endoparasite [1a]	No
<i>Mesocriconema onoensis</i> (syn. <i>Criconemella onoensis</i> , <i>Macroposthonia onoensis</i>)	Ring nematode	Ectoparasite [1d]	Yes
<i>Pratylenchus brachyurus</i>	Root-lesion nematode	Migratory endoparasite [1b]	Yes
<i>Pratylenchus coffeae</i>	Banana root nematode	Migratory endoparasite [1b]	Yes
<i>Pratylenchus zeae</i>	Root-lesion nematode	Migratory endoparasite [1b]	Yes
<i>Radopholus similis</i>	Burrowing nematode	Migratory endoparasite [1b]	Yes
<i>Rotylenchulus reniformis</i>	Reniform nematode	Sedentary semi-endoparasite [1a]	No
<i>Xiphinema brevicolle</i>	Dagger nematode	Ectoparasite [1d]	No
<i>Xiphinema ensiculiferum</i>	Dagger nematode	Ectoparasite [1d]	No
<i>Xiphinema insigne</i>	Dagger nematode	Ectoparasite [1d]	No

¹ Usually *Helicotylenchus* spp. are ectoparasitic feeders on roots, but they can sometimes feed inside the roots (Luc *et al.* 1990, as cited in Biosecurity Australia 2011)

It must be noted that nematodes of two genera, *Aphelenchoides* and *Aphelenchus*, make up a significant proportion of the identified interceptions (n=362; 79%). Better definition of the species involved, even if not formally described, and clarification of their feeding habits (plant parasites or fungivores) could assist NZ MAF revise its assessment of the quarantine status of the intercepted nematodes. An approach similar to Biosecurity Australia's (Biosecurity Australia 2011) could be suggested/requested if information was available (refer text box below).

The *Review of import conditions for fresh taro corms* documented Biosecurity Australia's (2011) analysis of the quarantine risks associated with the importation of fresh taro (*Colocasia esculenta*) from all countries. The analysis was undertaken in three consecutive stages:

1. Stage 1 – Initiation, which identifies the pest(s) and pathway(s) that are of quarantine concern and should be considered for risk analysis in relation to the identified area. **41 nematode species were identified, 14 of which there was no record of their presence in Australia. Six of the 14 were recorded as NOT having “potential to be on taro corms”.**
2. Stage 2 – Pest categorisation, which identifies which of the pests with the potential to be on the commodity are quarantine pests for Australia and require pest risk assessment. **Of the eight nematodes NOT present in Australia AND with potential to be on taro corms, four did NOT require detailed pest risk assessment** [one of which was assessed as having NO “potential for establishment and spread” with the remaining three assessed as having NO “potential for economic consequences”]. **Four nematodes were identified as quarantine pests** [two of which are in Fiji].
3. Stage 3 – Pest risk assessment. **The resulting unrestricted risk estimates were VERY LOW for three quarantine nematode species and NEGLIGIBLE for the fourth.**

3 Summary

Table 3-1 summarises information contained in Table 2-1 – Table 2-4 and provides a detailed list of nematodes recorded on taro, *Colocasia esculenta*, in Fiji. It contains data that may be relevant to any New Zealand review of the quarantine status of nematodes appearing on Fiji’s list of nematodes associated with taro.

Table 3-1 List of nematodes recorded on taro, *Colocasia esculenta*, in Fiji showing their quarantine status in New Zealand

Species	Common name	Order:Family	Feeding habit (according to Yeates <i>et al.</i> 1993)	Presence in Fiji	Presence in New Zealand	Quarantine status in New Zealand (BORIC)	Comments
<i>Aphelenchoides bicaudatus</i>	No common name	Aphelenchida: Aphelenchoididae	Hyphal feeding [2]	Orton-Williams 1980	No (Knight et al. 1997; Knight 2001)	Regulated	<i>Aphelenchoides</i> sp. frequent interception on Fiji taro. <i>A. bicaudatus</i> for which there are records on taro, considered by Biosecurity Australia (2011) to have no potential to be on corms processed for export. Hyphal feeders have no potential for economic consequences and should therefore be non-regulated. A few species of <i>Aphelenchoides</i> , including <i>A. fragariae</i> and <i>A. ritzemabosi</i> , are foliar feeders. Both these species are well established in New Zealand (Knight et al. 1997).

Species	Common name	Order:Family	Feeding habit (according to Yeates <i>et al.</i> 1993)	Presence in Fiji	Presence in New Zealand	Quarantine status in New Zealand (BORIC)	Comments
<i>Aphelenchoides</i> spp.	–	Aphelenchida: Aphelenchoididae	Hyphal feeding [2], 1b, 1e or 1f	Orton-Williams 1980	–	– Note: In the absence of named species information Regulated.	<i>Aphelenchoides</i> sp. frequent interception on Fiji taro. <i>A. besseyi</i> and <i>A. bicaudatus</i> for which there are records on taro, considered by Biosecurity Australia (2011) to have no potential to be on corms processed for export. Hyphal feeders have no potential for economic consequences and should therefore be non-regulated. A few species of <i>Aphelenchoides</i> , including <i>A. fragariae</i> and <i>A. ritzemabosi</i> , are foliar feeders. Both these species are well established in New Zealand (Knight <i>et al.</i> 1997).
<i>Aphelenchus</i> sp.	–	Aphelenchida: Aphelenchidae	Hyphal feeding [2], or 1f	NZ MAF Border Interception Records 2004–2005 (Table 2-3 above)	–	– Note: In the absence of named species information Regulated.	<i>Aphelenchus</i> sp. frequent interception on Fiji taro. <i>A. avenae</i> for which there are records on taro, considered by Biosecurity Australia (2011) to have no potential to be on corms. Hyphal feeders have no potential for economic consequences and should therefore be non-regulated.

Species	Common name	Order:Family	Feeding habit (according to Yeates <i>et al.</i> 1993)	Presence in Fiji	Presence in New Zealand	Quarantine status in New Zealand (BORIC)	Comments
<i>Caloosia longicaudata</i>	Ring nematode	Tylenchida: Caloosiidae	Ectoparasite [1d]	Orton-Williams 1980	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	Considered by Biosecurity Australia (2011) to have no potential to be on corms. As a root feeding ectoparasite is unlikely to be on corms and should therefore be non-regulated.
<i>Criconemella denoudenii</i> (syn. <i>Macroposthonia denoudenii</i>)	Ring nematode	Tylenchida: Criconematidae	Ectoparasite [1d]	Kirby <i>et al.</i> 1980 (as <i>Macroposthonia denoudenii</i>) Orton-Williams 1980 (as <i>Macroposthonia denoudenii</i>)	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	Considered by Biosecurity Australia (2011) to have no potential to be on corms. As a root feeding ectoparasite is unlikely to be on corms and should therefore be non-regulated.
<i>Discocriconemella</i> sp.	–	Tylenchida: Criconematidae	Ectoparasite [1d]	Kirby <i>et al.</i> 1980 Orton-Williams 1980	–	– Note: In the absence of named species information Regulated.	As a root feeding ectoparasite is unlikely to be on corms and should therefore be non-regulated.

Species	Common name	Order:Family	Feeding habit (according to Yeates <i>et al.</i> 1993)	Presence in Fiji	Presence in New Zealand	Quarantine status in New Zealand (BORIC)	Comments
<i>Ditylenchus</i> spp.	Stem and bulb nematodes	Tylenchida: Anguinidae	Hyphal feeding [2], or migratory endoparasites [1b] (mainly in shoots)	Orton-Williams 1980	–	– Note: In the absence of named species information Regulated.	<i>Ditylenchus</i> sp. rarely intercepted on Fiji taro. Is unlikely to be on corms; <i>Ditylenchus</i> species are hyphal feeders or parasites of plant stems and leaves, and should therefore be non-regulated. <i>D. dipsaci</i> , a wellknown nematode pest in temperate climates is well established in New Zealand (Knight <i>et al.</i> 1997).
<i>Gracilacus aonli</i>	No common name	Tylenchida: Paratylenchidae	Ectoparasite [1d]	Orton-Williams 1985	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	<i>Gracilacus</i> sp. rarely intercepted on Fiji taro. Considered by Biosecurity Australia (2011) to have no potential to be on corms. As a root feeding ectoparasite is unlikely to be on corms and should therefore be non-regulated.
<i>Gracilacus</i> sp.	–	Tylenchida: Paratylenchidae	Ectoparasite [1d]	Orton-Williams 1980	–	– Note: In the absence of named species information Regulated.	<i>Gracilacus</i> sp. rarely intercepted on Fiji taro. As a root feeding ectoparasite is unlikely to be on corms and should therefore be non-regulated.
<i>Helicotylenchus crenacauda</i>	Spiral nematode	Tylenchida: Hoplolaimidae	Semi-endoparasite [1c]	Orton-Williams 1980	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	<i>Helicotylenchus</i> spp. intercepted on Fiji taro.

Species	Common name	Order:Family	Feeding habit (according to Yeates <i>et al.</i> 1993)	Presence in Fiji	Presence in New Zealand	Quarantine status in New Zealand (BORIC)	Comments
<i>Helicotylenchus dihystra</i>	Common spiral nematode	Tylenchida: Hoplolaimidae	Semi-endoparasite [1c]	Kirby <i>et al.</i> 1980 Orton-Williams 1980	Yes (Knight <i>et al.</i> 1997; Knight 2001)	Non-regulated	<i>Helicotylenchus</i> spp. intercepted on Fiji taro.
<i>Helicotylenchus erythrinae</i>	Spiral nematode	Tylenchida: Hoplolaimidae	Semi-endoparasite [1c]	Kirby <i>et al.</i> 1980	Yes (Knight <i>et al.</i> 1997, Table 1)	Regulated	<i>Helicotylenchus</i> spp. intercepted on Fiji taro. Records of <i>H. erythrinae</i> in New Zealand suggests its status as Regulated should be reviewed.
<i>Helicotylenchus indicus</i>	Spiral nematode	Tylenchida: Hoplolaimidae	Semi-endoparasite [1c]	Orton-Williams 1980	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	<i>Helicotylenchus</i> spp. intercepted on Fiji taro.
<i>Helicotylenchus microcephalus</i>	Spiral nematode	Tylenchida: Hoplolaimidae	Semi-endoparasite [1c]	Orton-Williams 1980	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	<i>Helicotylenchus</i> spp. (including <i>H. microcephalus</i>) intercepted on Fiji taro.
<i>Helicotylenchus mucronatus</i>	Spiral nematode	Tylenchida: Hoplolaimidae	Semi-endoparasite [1c]	Orton-Williams 1980	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	<i>Helicotylenchus</i> spp. (including <i>H. mucronatus</i>) intercepted on Fiji taro.
<i>Helicotylenchus multincinctus</i>	Banana spiral nematode	Tylenchida: Hoplolaimidae	Semi-endoparasite [1c]	Kirby <i>et al.</i> 1980 Orton-Williams 1980	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	<i>Helicotylenchus</i> spp. intercepted on Fiji taro.
<i>Helicotylenchus pseudorobustus</i>	Spiral nematode	Tylenchida: Hoplolaimidae	Semi-endoparasite [1c]	McKenzie <i>et al.</i> 2003 McKenzie <i>et al.</i> 2005	Yes (Knight <i>et al.</i> 1997; Knight 2001)	Non-regulated	<i>Helicotylenchus</i> spp. (including <i>H. pseudorobustus</i>) intercepted on Fiji taro.
<i>Helicotylenchus</i> spp.	Spiral nematodes	Tylenchida: Hoplolaimidae	Semi-endoparasite [1c]	Orton-Williams 1980 McKenzie <i>et al.</i> 2003 McKenzie <i>et al.</i> 2005 Unaisi Turaganivalu (pers. comm.)	–	– Note: In the absence of named species information Regulated.	<i>Helicotylenchus</i> spp. intercepted on Fiji taro.

Species	Common name	Order:Family	Feeding habit (according to Yeates <i>et al.</i> 1993)	Presence in Fiji	Presence in New Zealand	Quarantine status in New Zealand (BORIC)	Comments
<i>Hemicriconemoides cocophilus</i>	No common name	Tylenchida: Criconematidae	Ectoparasite [1d]	McKenzie <i>et al.</i> 2003 McKenzie <i>et al.</i> 2005	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	Considered by Biosecurity Australia (2011) to have no potential to be on corms. As a root feeding ectoparasite is unlikely to be on corms and should therefore be non-regulated.
<i>Meloidogyne arenaria</i>	Peanut root-knot nematode	Tylenchida: Heteroderidae	Sedentary endoparasite [1a]	Kirby <i>et al.</i> 1980 Orton-Williams 1980 Khurma <i>et al.</i> 2008 Singh 2009	Yes (Knight <i>et al.</i> 1997, Table 1)	Regulated (as <i>M. thamesi</i>)	<i>Meloidogyne</i> spp. rarely intercepted on Fiji taro. Considered by Biosecurity Australia (2011) to have no potential to be on corms. Records of <i>M. arenaria</i> in New Zealand suggests its status as Regulated should be reviewed.
<i>Meloidogyne incognita</i>	Root-knot nematode	Tylenchida: Heteroderidae	Sedentary endoparasite [1a]	Kirby <i>et al.</i> 1980 Orton-Williams 1980 Khurma <i>et al.</i> 2008 Singh 2009	Yes (Knight <i>et al.</i> 1997; Mercer and Miller 1997)	Non-regulated	<i>Meloidogyne</i> spp. rarely intercepted on Fiji taro. Considered by Biosecurity Australia (2011) to have no potential to be on corms.
<i>Meloidogyne javanica</i>	Sugarcane eelworm	Tylenchida: Heteroderidae	Sedentary endoparasite [1a]	Kirby <i>et al.</i> 1980 Orton-Williams 1980 McKenzie <i>et al.</i> 2003 McKenzie <i>et al.</i> 2005 Khurma <i>et al.</i> 2008 Singh 2009	Yes (Knight <i>et al.</i> 1997; Mercer and Miller 1997)	Non-regulated	<i>Meloidogyne</i> spp. rarely intercepted on Fiji taro. Considered by Biosecurity Australia (2011) to have no potential to be on corms.

Species	Common name	Order:Family	Feeding habit (according to Yeates <i>et al.</i> 1993)	Presence in Fiji	Presence in New Zealand	Quarantine status in New Zealand (BORIC)	Comments
<i>Meloidogyne</i> spp.	Root-knot nematodes	Tylenchida: Heteroderidae	Sedentary endoparasites [1a]	Orton-Williams 1980 McKenzie <i>et al.</i> 2005 Unaisi Turaganivalu (pers. comm.)	–	– Note: In the absence of named species information Regulated.	<i>Meloidogyne</i> spp. rarely intercepted on Fiji taro. Considered by Biosecurity Australia (2011) to have no potential to be on corms.
<i>Mesocriconema onoensis</i> (syn. <i>Criconemella onoensis</i> , <i>Macroposthonia onoensis</i>)	Ring nematode	Tylenchida: Criconematidae	Ectoparasite [1d]	Kirby <i>et al.</i> 1980 (as <i>Macroposthonia onoensis</i>) Orton-Williams 1980 (as <i>Macroposthonia denoudenii</i>) McKenzie <i>et al.</i> 2003 (as <i>Macroposthonia onoensis</i>) McKenzie <i>et al.</i> 2005 (as <i>Macroposthonia onoensis</i>) Secretariat of the Pacific Community (as <i>Criconemella onoensis</i>)	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated (as <i>Criconemella onoensis</i>)	
<i>Pratylenchus brachyurus</i>	Root-lesion nematode	Tylenchida: Pratylenchidae	Migratory endoparasite [1b]	Orton-Williams 1980	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	<i>Pratylenchus</i> spp. intercepted on Fiji taro.

Species	Common name	Order:Family	Feeding habit (according to Yeates <i>et al.</i> 1993)	Presence in Fiji	Presence in New Zealand	Quarantine status in New Zealand (BORIC)	Comments
<i>Pratylenchus coffeae</i>	Banana root nematode	Tylenchida: Pratylenchidae	Migratory endoparasite [1b]	Kirby <i>et al.</i> 1980 Orton-Williams 1980	Yes (Knight <i>et al.</i> 1997, Table 2)	Regulated	<i>Pratylenchus</i> spp. (including <i>P. coffeae</i>) intercepted on Fiji taro. Records of <i>P. coffeae</i> in New Zealand suggests its status as Regulated should be reviewed.
<i>Pratylenchus zeae</i>	Root-lesion nematode	Tylenchida: Pratylenchidae	Migratory endoparasite [1b]	Orton-Williams 1980	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	<i>Pratylenchus</i> spp. intercepted on Fiji taro.
<i>Pratylenchus</i> sp.	–	Tylenchida: Pratylenchidae	Migratory endoparasite [1b]	Orton-Williams 1980 McKenzie <i>et al.</i> 2003 McKenzie <i>et al.</i> 2005 Unaisi Turaganivalu (pers. comm.)	–	– Note: In the absence of named species information Regulated.	<i>Pratylenchus</i> spp. intercepted on Fiji taro.
<i>Radopholus similis</i>	Burrowing nematode	Tylenchida: Pratylenchidae	Migratory endoparasite [1b]	Kirby <i>et al.</i> 1980 Orton-Williams 1980	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	
<i>Rotylenchulus reniformis</i>	Reniform nematode	Tylenchida: Hoplolaimidae	Sedentary semi-endoparasite [1a]	Kirby <i>et al.</i> 1980 Orton-Williams 1980 McKenzie <i>et al.</i> 2003 (Appendix 5) Unaisi Turaganivalu (pers. comm.)	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	<i>Rotylenchulus reniformis</i> rarely intercepted on Fiji taro. Considered by Biosecurity Australia (2011) to have no potential to be on corms. As a sedentary root feeding nematode is unlikely to be on corms and should therefore be non-regulated.

Species	Common name	Order:Family	Feeding habit (according to Yeates <i>et al.</i> 1993)	Presence in Fiji	Presence in New Zealand	Quarantine status in New Zealand (BORIC)	Comments
<i>Xiphinema brevicollum</i> (previously <i>X. brevicolle</i> ; one of the <i>X. americanum</i> group)	Dagger nematode	Dorylaimida: Longidoridae	Ectoparasite [1d]	Kirby <i>et al.</i> 1980 (as <i>Xiphinema brevicolle</i>) Orton-Williams 1980 (as <i>Xiphinema brevicolle</i>)	Yes (Knight <i>et al.</i> 1997, as <i>X. americanum</i> (sensu lato); Knight 2001, as <i>X. americanum</i>)	Non-regulated	Considered by Biosecurity Australia (2011) to have no potential to be on corms. As a root feeding ectoparasite is unlikely to be on corms and should therefore be non-regulated.
<i>Xiphinema ensiculiferum</i>	Dagger nematode	Dorylaimida: Longidoridae	Ectoparasite [1d]	Kirby <i>et al.</i> 1980 Orton-Williams 1980	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	Considered by Biosecurity Australia (2011) to have no potential to be on corms. As a root feeding ectoparasite is unlikely to be on corms and should therefore be non-regulated.
<i>Xiphinema insigne</i>	Dagger nematode	Dorylaimida: Longidoridae	Ectoparasite [1d]	Orton-Williams 1980	No (Knight <i>et al.</i> 1997; Knight 2001)	Regulated	Considered by Biosecurity Australia (2011) to have no potential to be on corms. As a root feeding ectoparasite is unlikely to be on corms and should therefore be non-regulated.

4 Conclusions and Recommendations

The main export markets for Pacific Island taro are New Zealand and Australia. The competitiveness of taro in these markets can be significantly affected by the quarantine requirements. In recent years, the main quarantine issue associated with Fiji taro exports to New Zealand is the presence of nematodes. Frequently during on-arrival inspections of taro consignments nematodes are discovered and as a result most consignments exported to New Zealand are fumigated. Fumigation adds to the exporters' cost structure, and decreases the shelf-life of the product.

To clarify whether fumigation is a technically justifiable response to the discovery by New Zealand inspectors of nematodes in fresh taro consignments from Fiji, the work documented in this report aimed to:

- Develop a comprehensive list of nematode species associated with Fiji taro corms;
- Develop, in conjunction with Biosecurity Authority Fiji and industry, a submission to the New Zealand Ministry of Agriculture and Forestry outlining the nematode species found on Fiji taro and their quarantine status in New Zealand; and
- If necessary, work with Biosecurity Authority Fiji to determine an operational policy to ensure that, if detected, only nematode species of quarantine concern require on-arrival quarantine measures.

Substantive works documenting the results of host/pest surveys in Fiji were Orton-Williams (1980), Kirby *et al.* (1980) and McKenzie *et al.* (2003; 2005). In isolation none of these works provided a comprehensive list of nematodes recorded on taro, *Colocasia esculenta*, in Fiji. For instance, in the survey of Fiji agricultural crops and commodities, McKenzie *et al.* (2005) collected only soil samples for extraction of nematodes, and acknowledged that the survey was not well suited for detecting the presence of stem and foliar nematodes belonging to the genera, *Aphelenchoides* and *Ditylenchus*. Collectively however, these works provided most of the documented and accessible records of nematodes recorded on taro, *Colocasia esculenta*, in Fiji.

Based on the results of the aforementioned host/pest surveys, a list of nematodes associated with taro has been compiled. The list includes nematodes of the genera *Aphelenchoides*, *Helicotylenchus*, *Meloidogyne*, *Pratylenchus*, and *Xiphinema*, as well as *Radopholus similis* and *Rotylenchulus reniformis*. Most of the nematodes fall, or potentially fall, into groups described as 'plant parasitic', and most (80%) of those that can be categorised, are categorised by NZ MAF as 'regulated pests' for New Zealand. Unfortunately, some of the nematodes collected during the surveys of Orton-Williams (1980), Kirby *et al.* (1980) and McKenzie *et al.* (2003; 2005) were identified (and recorded) to genus level only. For quarantine purposes, including pest risk analyses and market access submissions, it is preferable for organisms associated with a particular commodity to be listed to species level. In the absence of named species details, NZ MAF regards any organism as 'Regulated'.

The opportunity exists to obtain clarification of all the nematodes of potential concern likely to occur in Fiji's taro export pathway. There are two ACIAR projects – the *Cleaner Pathways* (PC/2007/118) and *Soil Health* (PC/2009/003) projects – that are now underway in Fiji and Samoa. Components of both projects involve soil and taro root sampling, extraction of nematodes from the samples and subsequent identification of the nematodes. Discussion with some researchers involved with the projects indicates that identifications undertaken will be to genus level only. It is understood that for some genera, morphological keys are available for subsequent species identification, but for others specimens could be prepared for molecular diagnosis and/or examination by experts to ensure

species identifications are pursued. Advantage should be taken of this opportunity, particularly to clarify the species and feeding habits (as plant parasites or fungivores) of *Aphelenchoides* spp. and *Aphelenchus* spp. given past interception records of nematodes on consignments of Fijian taro on-arrival in New Zealand.

Since 31 March 2006 identification of nematode interceptions from taro imports at New Zealand's border have been rarely pursued. However, NZ MAF Border Interception Records for the period 1 January 2004 – 31 December 2005, the most recent and detailed New Zealand nematode interception dataset available, indicated that two genera, *Aphelenchoides* and *Aphelenchus*, made up a significant proportion of the identified interceptions (n=362; 79%) of nematodes on Fijian taro.

In conclusion, the following recommendations are made:

- *Arrange* for species-level identification (if appropriate from international experts), when technically possible, of those nematodes extracted from samples collected in the course of the ACIAR-funded *Cleaner Pathways* and *Soil Health* projects;
- Where possible, *coordinate* and/or *combine* soil and taro root sampling planned as part of the two ACIAR-funded projects in order to ensure adequate sample numbers from representative sites and valid comparative analyses of the results subsequently;
- *Update* the list of nematodes associated with taro from Fiji (as presented in this report) as species information is clarified from current sampling; and
- *Request* NZ MAF (now the Ministry for Primary Industries) to review the quarantine status of nematodes in the genera *Aphelenchoides*, *Aphelenchus* and those 'regulated' ectoparasitic nematodes appearing on Fiji's list of nematodes associated with taro (and provided in Summary, Table 3-1).

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6 Limitations

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Appendix A

Appendix A List of Persons Consulted

Losalini Leweniqila	PHAMA Fiji Market Access Coordinator
Waisiki Gonemaituba	Biosecurity Authority Fiji
Visoni Timote	Plant Pathologist, Biosecurity Authority Fiji
Unaisi Turaganivalu	Senior Technical Assistant, Plant Pathology, Plant Protection Section, Ministry of Agriculture and Primary Industries
Takaniko Ruabete	Plant Pathology Technician, Land Resources Division, Secretariat of the Pacific Community



URS

URS Australia Pty Ltd
Level 4, 70 Light Square
Adelaide SA 5000
Australia

T: 61 8 8366 1000

F: 61 8 8366 1001

www.ap.urscorp.com