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CONTENTS

PEST SPECIES OF THE GENUS *ORIBIUS* MARSHALL (COLEOPTERA: CURCULIONIDAE) IN PAPUA NEW GUINEA

Mark M Ero[1,2], Anthony R Clarke[2], Pus Wesis[3] and Benjamin Niangu[3]

ABSTRACT

The genus Oribius *Marshall (Coleoptera: Curculionidae) contains a number of important agricultural pest species within PNG. Unfortunately, the taxonomy of the group is poorly known and current and future agricultural research is limited by the inability to identify these insects. As an aid to applied research, and future taxonomic studies, a preliminary assessment of the genus* Oribius *was undertaken.* Oribius *contains 25 formally described species and a further 30 species, provisionally placed in the genus. The status of these provisionally placed species remains uncertain. Seven pest species are identified from Papua New Guinea, five which were confirmed to species level (*O. cinereus *Marshall,* O. cruciatus *(Faust),* O. destructor *Marshall,* O. improvidus *Marshall,* O. inimicus *Marshall) and two which may be new (*Oribius *sp. near* leucopleurus *(Faust) and* Oribius *sp.1). A diagnosis for each of these seven species is provided, as is a key for their identification.*

***Key words**: grey weevils, PNG agriculture, pest management, Otiorrhynchinae, Celeuthetini*

INTRODUCTION

Weevils (Coleoptera: Curculionidae) of the genus *Oribius* Marshall, commonly known as either oribius weevils or grey weevils, are abundant throughout Papua New Guinea (PNG) and West Papua. *Oribius* species are restricted to the island of New Guinea (Thomas & Verloop 1962) and the northern tip of Cape York, Australia (Zimmerman 1991). Adults of *Oribius* spp are flightless and walk onto their host plants where they feed on leaves, soft shoots, green stems, flower buds and developing fruits (Thistleton 1984). Pest species of *Oribius* attack a wide range of agricultural crops, from leafy greens through to introduced orchard trees and field crops such as coffee (Marshall 1957, 1959; Szent-Ivany 1959; Szent-Ivany & Stevens 1966; Greve & Ismay 1983; Thistleton 1984; Waterhouse 1997). *Oribius* spp are also recorded as forestry pests (Gray & Wylie 1974) and they are an abundant component of the PNG rainforest insect fauna (Novotny *et al.* 2002). Feeding by *Oribius* causes significant loss of growth, yield decline, downgrade of crop marketability and, in severe cases, tree and seedling mortality.

Taxonomically, *Oribius* is poorly worked and identification of even the common pest species is difficult. This limits the ability to carry out sound scientific research on the pests, as effective pest management should be built upon a basis of knowing the species status of the animals being studied (Walter 2003). As an aid to applied research, this paper presents a taxonomic history and synopsis of the genus, distribution of species where known, diagnostic descriptions of seven PNG pest species and a key to those species. The seven pest species have been identified through literature records and from original research (see Acknowledgements).

MATERIALS AND METHODS

Materials examined

Materials examined came from museum held specimens as well as fresh field collected specimens. Museum specimens examined were held at the sub-regional insect collections of the National Agricultural Research Institute of Papua New Guinea (located at Kila Kila- Port Moresby, Bubia- Lae and Kerevat- Rabaul); Forest Research Institute of Papua New Guinea Insect Collection, Lae; New Guinea Binatang Research Centre Collection, Madang and Queensland Museum, Brisbane, Australia. Type specimens of *O. destructor* and *O. inimicus* were loaned from the British Museum of Natural History (BMNH). Fresh

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specimens were collected from Central, Morobe, Madang, Eastern Highlands, Chimbu, Western Highlands and Southern Highlands Provinces. Most specimens were examined at the National Agricultural Insect Collection in Kila Kila, Port Moresby. Illustrations were done at the Queensland University of Technology, Brisbane, Australia. All of the field collected specimens are housed at the National Agricultural Insect Collection.

Terminology

Most of the morphological terminology used follows that of Marshall (1956).

***Taxonomic history of the genus* Oribius**

Taxonomic work on species formally or provisionally placed within *Oribius* dates from the mid-1800s to the mid-1900's (Gerin 1841; Blanchard 1850, 1853; Pascoe 1871, 1885; Faust 1897, 1899; Lea 1910, 1927a,b; Heller, 1935; Marshall 1915, 1956, 1957, 1959). The only comprehensive work on the genus was pursued by Marshall, but ceased with his death in 1959. Excluding photographs of the Australian *Oribius* species (Zimmerman, 1991), there has been no further published work on *Oribius* since Marshall's last paper.

The genus *Oribius* Marshall (Family Curculionidae: Sub-family Otiorrhynchinae: Tribe Celeuthetini) was erected to accommodate species that were earlier placed within the genus *Coptorhynchus* Guérin-Méneville 1841 (Marshall, 1956). Marshall (1959) separated *Oribius* from *Coptorhynchus* based on the following morphological characters: *head separated from the rostrum by a curved or angulate sulcus; antennal scape slender, cylindrical and setose; 10 striae on the elytra with the 10th stria complete and parallel with the ninth; femora of leg clavate with minute teeth and the sternum with the mesosternal process about as long as its least width or somewhat longer.* This contrasts with *Coptorhynchus*, where: *head is separated from the rostrum by a transverse sulcus; antennal scape thick and squamose with stiff curved setae; 10 striae on elytra with the 10th stria entirely obliterated behind the metasternum; femora of leg moderately clavate with two or three minute teeth on the lower surface, and the sternum with the mesosternal process much longer than its least width.*

As given by Marshall (1957), the formal diagnosis of the genus *Oribius* is as follows: *Head separated from the rostrum by a curved or angulate sulcus, not constricted behind the eyes, which are moderately and evenly convex. Rostrum parallel-sided, with (type) or without a low elevation above the abrupt apical declivity, which is devoid of scales; mentum resting on a short peduncle. Antennae with the scape slender, cylindrical, setose only; funnicle with all the joints longer than broad. Prothorax truncate at the base and there wider than the apex, which is obliquely truncate laterally, granulate or granulato-punctate. Elytra ovate, with 10 striae, the tenth complete and parallel with the ninth. Legs slender, the femora clavate, the hind pair varying in length, not reaching the apex of the elytra in some and exceeding it in others; tibiae not denticulate, the front pair straight dorsally. Sternum with the front coxae subcontiguous or very narrowly separated, nearer to the front margin of the prosternum; mesosternal process about as long as its least width (type) or somewhat longer. Venter with ventrite 2 longer than 3 and 4.* The type species of the genus is *Oribius generosus* (Faust, 1897) and the type locality is 'New Guinea' (specific locality not given).

Twenty-two *Coptorhynchus* species were transferred into *Oribius* by Marshall (1956), while a few more were transferred from other related genera. Marshall provisionally assigned a further 30 species to *Oribius*, but he was unable to confirm the genus change due to unavailability of type specimens (a problem which remains in the study of this group) (Table 1). After the erection of the genus, a further three species were described from Papua New Guinea: *O. destructor* Marshall, 1957, *O. inimicus* Marshall, 1957 and *O. cinereus* Marshall, 1959. In his revision of the tribe, Marshall (1956) presents a key to the tribe Celeuthetini (Otiorrhynchinae), which is extremely useful in helping to set limits to the genus.

Distribution of* Oribius *species

Oribius is restricted to the Island of New Guinea (Irian Jaya, Indonesia and Papua New Guinea), including some of its outer islands, and the northern tip of Queensland, Australia, including the Torres Strait Islands. Six species (*O. albivarius* (Lea), *O. equinus* (Lea), *O. gestroi* (Pascoe), *O. jansoni* (Pascoe), *O. tessellatus* (Blanchard), *O. trivittatus* (Lea)) have been described from Australia (Zimmerman 1991), while the remaining 18 species and all provisional species are known from the island of New Guinea. Distribution records of most New Guinean species remain unknown as records were simply given as 'New Guinea', without specific collection localities. The known provincial distributions of Papua New Guinea species are give in Table 2.

Table 1. Species formally or provisionally placed within the genus *Oribius* by Marshall (1956) and those species described subsequent to the erection of the genus.

Species formally placed into *Oribius*	*O. albivarius* (Lea), *O. ambiguus* (Faust), *O. bombylius* (Guer), *O. crassirostris* (Pascoe), *O. cruciatus* (Faust), *O. demeijerei* (Heller), *O. elegans* (Guérin-Méneville.), *O. equinus* (Lea), *O. generosus* (Faust), *O. gestroi* (Pascoe), *O. guttatus* (Pascoe), *O. guttiger* (Blanchard), *O. immitis* (Pascoe), *O. improvidus* (Marshall), *O. inornatus* (Pascoe), *O. jansoni* (Pascoe), *O. leucopleurus* (Faust), *O. leucostictus* (Pascoe), *O. servilis* (Pascoe), *O. subligatus* (Marshall), *O. tessellatus* (Faust), *O. trivittatus* (Lea)
Oribius species described after the erection of the genus	*O. cinereus* Marshall 1959; *O. destructor* Marshall 1957; *O. inimicus* Marshall 1957
Species provisionally placed into *Oribius*	*Coptorhynchus blanchardi* Faust; *C. bombycollius* Macleay.; *C. discretus* Faust; *C. distans* Faust; *C. ellipticus* Faust; *C. fraterculus* Faust ; *C. fuscipes* Faust ; *C. gratus* Faust ; *C. guineensis nom. nov. improvidus* Heller.; *O. hellerianus* nom. nov. *leucostictus* Heller; *C. hospes* Faust, *C. hostis* Heller; *C. humilis* Faust; *C. hypocritus* Faust; *C. indiscretus* Faust; *Psomeles lateralis* Boisduval; *P. lepidus* Boisduval; *C. melancholicus* Boisduval; *C. nudus* Macleay; *C. pellax* Faust; *C. peronartus* Heller; *C. puncticollis* Faust; *C. quadriplex* Heller; *C. 14-maculatus* Chevrolat; *C. speculatus* Macleay.; *C. suavis* Faust; *C. subcylindricus* Faust; *C. unifasciatus* Faust; *C. valens* Heller; *C. vittaticollis* Heller

Table 2. Provincial distribution records of *Oribius* Marshall species within Papua New Guinea. [Abbreviations: NCD-SL: National Capital District-Specimen Label; NAIC-SL: National Agricultural Insect Collection-Specimen Label; QM-SL: Queensland Museum-Specimen Label]

***Oribius* spp.**	**Provincial Distribution**	**Reference/Source**
O. bombylius (Guérin-Méneville)	Western	Lona 1937; Pascoe 1885
O. cinereus Marshall	Morobe, Madang	NAIC-SL; QM-SL; Szent-Ivany & Stevens 1966; Marshall 1959
O. cruciatus Faust	Morobe, Central, NCD, Sandaun, Gulf, Oro	NAIC-SL; Gray & Wylie 1974; Faust 1897, 1899; Lona 1937; Szent-Ivany 1959
O. destructor Marshall	Southern Highlands, Eastern Highlands, Western Highlands, Enga, Chimbu, Morobe, Madang, Central, Gulf	NAIC-SL; Gray & Wylie 1974; Marshall 1957; Szent-Ivany, 1959;
O. elegans (Guérin-Méneville)	Central	Pascoe 1885; Faust 1899; Lona 1937
O. generosus Faust	Milne Bay	Faust 1897, 1899; Lona 1937
O. guttatus (Pascoe)	Central	Lona 1937; Pascoe 1885
O. inimicus Marshall	Western Highlands, Eastern Highlands; Southern Highlands; Enga; Chimbu; Madang	NAIC-SL; Marshall 1957; Gray & Wylie 1974;
O. improvidus Marshall	Western	NAIC-SL; Pascoe 1885
O. servilis (Pascoe)	Central, Western	Faust 1899; Pascoe 1885

Key to, and descriptions of, PNG pest *Oribius* species

Key to the known pest species of* Oribius *from Papua New Guinea

1. Head and body completely covered with pale grey circular squamate scales, prothorax with suberect setae, elytra bristling with elongate setae; dorsum of rostrum with a sulcus and a deep emargination prior to abrupt apical declivity; body length 4-5 mm (Fig. 1)..... ***O. cinereus*** Marshall
   Head and body not completely covered with squamate scales, scales scattered sometimes forming distinct patterns..... 2
2(1). Dorsum of rostrum carinate..... 3
   Dorsum of rostrum with sulcus 4
3(2). Rostrum emarginated prior to abrupt apical declivity, dorsum with a distinct patch of white squamate scales; average body length 6.4 mm (Fig. 6) ..... ***O. sp. nr leucopleurus*** (Faust).
   Rostrum not emarginated prior to abrupt apical declivity 5
4(2). Rostrum not raised prior to abrupt apical declivity; elytra with two distinct lateral stripes; body length 5-6 mm (Fig.5)..... ***O. inimicus*** Marshall
   Rostrum conspicuously raised prior to abrupt apical declivity..... 6
5(3). Both mesepimeron and metepimeron with low lying scattered, easily abradable squamate scales; elytra with a mid band and stripes forming distinct pattern, average body length 8.8 mm (Fig.2)..... ***O. cruciatus*** (Faust)
   Mesepimeron without squamate scales but setae present; metepimeron with procumbent elonagte scales and fine elongate setae; elytra with three stripes (one mid and two lateral), the lateral stripes spread outwards at the abrupt apical declivity; body length 5.0-6.5 mm (Fig.3)..... ***O. destructor*** Marshall
6(4). Both femoral and tarsal segments almost completely covered with white circular squamate scales (sometimes inconspicuous); fore-tibiae serrated ventrally; body length 6.5-7.0 mm (Fig.4)..... ***O. improvidus*** Marshall
   Low lying and easily abradable white squamate scales present only on femoral segments, tarsal segments without scales; fore-tibiae serrated ventrally; average body length 7.6 mm (Fig.7)..... **O. sp 1**

Oribius cinereus Marshall, 1959 (Fig. 1)

Type: Holotype male, Windiluk Village, Saidor, Madang Province (3000 feet), Papua New Guinea. Type specimens deposited at the British Museum of Natural History (BMNH), London.

Diagnosis: Male and female. Derm shiny black with dense uniform pale grey scaling. *Head*: sparsely shallowly punctate and densely squamose; the frons flat, with a small elongate median fovea; the eyes nearly flat, not or very slightly exceeding the curvature of the head. *Rostrum*: about as long as broad, widening from the base to the genae, with the sides straight; the dorsal area narrowing from the base to the antennae, flat with dense scales and recumbent ribbon-like setae, the margins and the dorsum not carinate; the genae with long pale recumbent setae, but no scales, emarginate prior to abrupt apical declivity. *Antennae*: red-brown, the scape with pale recumbent setae, the funicle with the two basal joints equal. *Prothorax*: as long as broad, rounded laterally, widest behind the middle, the truncate apex distinctly narrower than the base; the dorsum moderately convex longitudinally, the punctures concealed by the dense scales and only the very small shinny granules showing through each giving rise to a short recumbent spatulate white seta, these later being more conspicuous at the base and sides; mesepimeron with scattered circular non-contiguous scales; metepimeron with contiguous circular squamate scales; prothoracic process with a patch of erect setae; mesothoracic process with a patch of decumbent elongate scales. *Elytra*: broadly ovate, widest before the middle, rather abruptly acuminate at the apex in the female, rather more gradually narrowed in the male; but otherwise extremely similar to the female; the dorsal outline more convex, highest at the middle, becoming rather abruptly perpendicular at the apex, the shallow stria with small separated punctures that show clearly through the dense scales; the intervals broader than the striae, flat with a row of short curved suberect setae, and some grey, more conspicuous on the declivity. *Legs*: black with dense grey scales and white recumbent setae; hind tibiae of the male with a very small angulation on the lower edge at one-fourth from the apex. *Genitalia*: Male with the apex of aedeagus not elongate and strongly rounded. Female with spermathecal gland not enlarged, spermatheca not Y-shaped and spermathecal duct not elongate.

Body length: 4 -5 mm.
Sexual dimorphism: Generally females are larger in size than the males. The meso- and meta-

sterna in males distinctively depressed than in females.

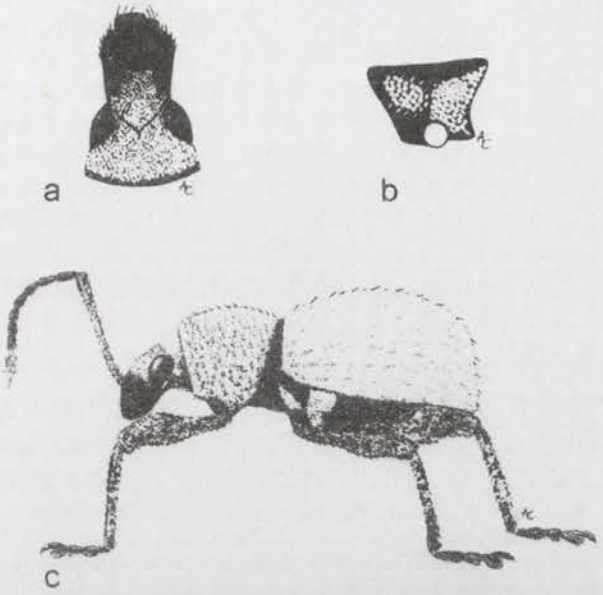

Figure 1. *Oribius cinereus* Marshall: (a) Habitus lateral view; (b) Head, dorsal view; (c) detail of mesepimeron and metepimeron, lateral view.

Oribius cruciatus (Faust 1897) (Fig. 2)
Coptorhynchus cruciatus Faust 1897

Type: Not available. Type series probably destroyed during World War II in the Dresden Museum, Germany.

Diagnosis: Derm black, sometimes light brown with stripes formed of whitish scales that are sometimes easily abraded; prothorax with dense patch of whitish scales forming lateral stripes from the base to the apex, wider at the base and narrowing at the apex, no scales on the pleurae; elytra with dense median stripe on stria 1 extending from the base to the apex, a dense perpendicular median band from stria 2 to the marginal stripe meeting below the hind coxae, gradually spreading at the marginal stripe, a dense stripe on stria 5 from apex to almost meeting the perpendicular band, the marginal stripe dense sometimes widening at the apex rarely meeting with the strip on stria 1; mesepimeron and metepimeron with scattered procumbent setae and without scales; prothoracic process devoid of scales; mesothoracic process without scales but with suberect elongate setae.
Head: separated from the rostrum by an angulate sulcus, not constricted behind the eyes, eyes moderately convex. *Rostrum*: parallel-sided, slightly longer than broad with a narrow carinate from the base to the apex before the declivity at dorsum, with slight elevation above the abrupt apical declivity, dorsum with scattered white setae. *Antennae*: scape slender, cylindrical and elongate, funnicle with all segments longer than broad, segment 2 longer than segment 1, all segments bearing sub-erect white setae. *Prothorax*: as long as broad, moderately rounded laterally, truncate at the base and as wide as the apex, widest at the middle, lightly punctuated, medium granules with white sub-erect setae, dorsum very much flattened. *Elytra* ovate, sub-compressed behind, dorsum more flattened, striae wide with wide deep punctures separated by raised granules, the intervals wider than the striae with rows of raised granules each bearing white sub-erect seta. *Legs*: dark brown with sub-erect white setae all over; small patch of white scales on the terminal enlarged ends of femur of all legs. *Genitalia*: Male with apex of aedeagus slightly elongate and narrowly rounded. Female with spermathecal gland enlarged so that spermatheca is more or less Y-shaped, spermathecal duct short and straight.

Body length: 8-9 mm
Sexual dimorphism: The only obvious differences between the males and females are in the meso- and meta-sternal structures and the body size. The meso- and meta-sterna of males are strongly depressed, while it is less pronounced in the females. The males are usually smaller in size than the females.

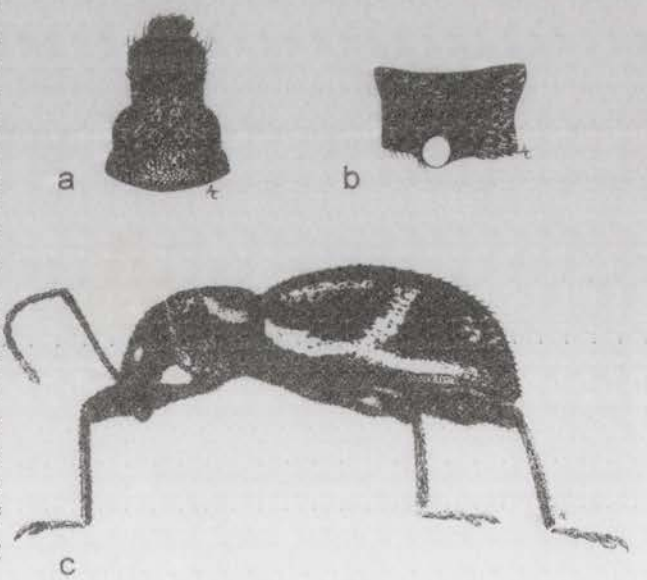

Figure 2. *Oribius cruciatus* (Faust): (a) Habitus lateral view; (b) Head, dorsal view; (c) detail of mesepimeron and metepimeron, lateral view.

Oribius destructor Marshall, 1959 (Fig. 3)

Type: Holotype male, C. Pentland's Coffee Plantation, Goroka, Eastern Highlands, New Guinea, 5200ft, J.J.H Szent-Ivany. Type specimens deposited at the British Museum of Natural History (BMNH), London.

Diagnosis: Derm shiny black with markings formed of small round whitish scales which can easily be abraded; prothorax with very sparse small scales (always present on the propleurae) and fairly dense strip from the base to the middle; elytra with a stripe on interval (I) from the scutellum to the top of the declivity, a dense complete stripe covering the lateral margin, a dense complete stripe covering the lateral margin inwards to stria 9, and a less dense complete stripe on intervals 5 and 6, which on the declivity spreads broadly outwards to unite with the lateral stripe; the sternum with a loose patch of recumbent white setae and narrow scales at the side of the metepimeron only, mesepimeron without scales; the venter of the male with rather dense long soft erect pale setae, which are shorter, sparser and stiffer in the female; prothoracic and mesothoracic processes without scales but with soft erect pale setae as well as a few elongate white setae. *Head*: vertex smooth and almost impunctate, frons with a few coarse punctures and a short deep median sulcus, eyes moderately convex. *Rostrum*: longer than broad (7:5), very gradually widening from the base to the genae; the median dorsal area nearly parallel sided, coarsely punctate, with low smooth median carina and with a slight elevation between the antennae. *Antennae*: black or piceous, with the funicular joints elongate, joint 2 a little longer than 1. *Prothorax*: B& globose, very strongly rounded laterally, widest at the middle, a little broader than long, the arcuate apical margin narrower than the base, which is widely but shallowly sinuate with a broad carinate margin; the dorsum very strongly convex in both directions, highest at the middle, with close (but not quite continuous), small oval low granules, which become much flattened towards the sides and base and are replaced on the pleurae by very small sparse convex granules, each dorsal granule with a short recumbent pale seta; @& similar but narrower, the dorsal granules not (or but slightly) flattened laterally, and the pleural grains larger. *Elytra*: narrowly ovate in the B&, broader and rather more acuminate apically in the @&, but the apex not produced downwards, the shallow striae with rather large close punctures separated by low flattened granules (sometimes almost obliterated) which often tend to link up laterally with the granules in the adjoining striae; the intervals not, or but little wider than the striae with a sparse row of small low granules, each bearing a short sub-erect white seta. *Legs*: black with sparse erect white setae, the tibiae of the B& (especially the front pair) with a fringe of long soft erect setae, the front tibiae feebly denticulate beneath in both sexes, and those of the B& incurved at the apex; the hind femora of the B& reaching or slightly exceeding the apex of the elytra. *Genitalia*: Male with apex of aedeagus pointed. Female with spermathecal gland enlarged so that spermatheca is more or less Y-shaped, spermathecal duct very long and coiled.

Body length: 5.0 - 6.5 mm.

Sexual dimorphism: Male with hind body narrow and all legs with dense long fringes of pale soft hairs. Females in contrast with the hind body broad and round and legs with short, sparse hairs.

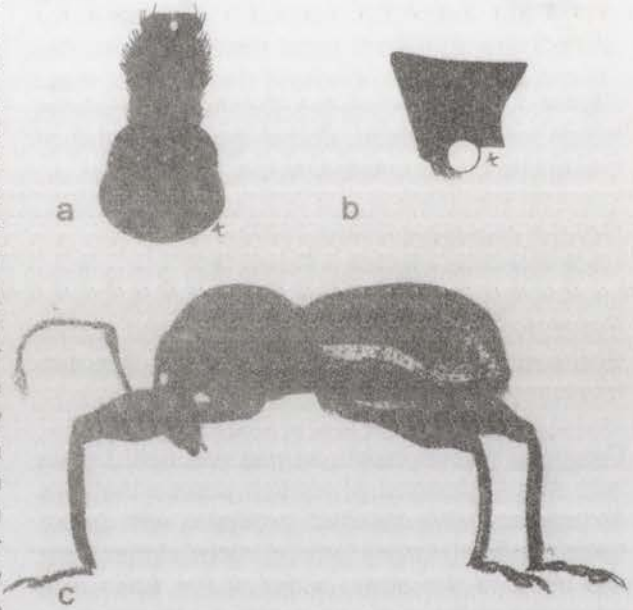

Figure 3. *Oribius destructor* Marshall: (a) Habitus lateral view; (b) Head, dorsal view; (c) detail of mesepimeron and metepimeron, lateral view.

Oribius improvidus (Marshall 1915) (Fig. 4)
Coptorhynchus improvidus Marshall 1915

Type: Cotype (male and female), Mimika River, Irian Jaya, Indonesia. Location of the type series not known (possibly at the British Museum of Natural History, London).

Diagnosis: Colour shining black and piceous, with rather sparse, almost circular, grey and white scales; elytra with an opaque postmedian denuded band, extending from the margin (where it is broadened) to the first stria, and a small denuded preapical patch; the sides of the sternum with

dense white or greyish scaling; prothoracic process bare of scales and setae; mesothoracic process with white suberect erect setae and without scales.
Head: finely rugose, the forehead with a short central stria. *Rostrum*: with the central almost plane, dorsum with sulcus, raised above abrupt apical declivity, the space between the scrobes broader than the club of the scape. *Antennae*: with the second joint of the funnicle much longer than the first. *Prothorax*: as long as broad, the sides strongly rounded, broadest in the middle, the apex distinctly narrower than the base, the upper surface rugose and fairly closely set with shining granules, each bearing a curved white seta, the sides more or less reticulately punctate and the granules small or absent. *Elytra*: ovate, acuminate and subcompressed behind, the suture elevated on the declivity, more especially in female, the apex in the male slightly produced downwards, the dorsal outline of the male gently convex to the declivity, which is very steep and slightly sinuate, the outline of the female flatter being steeper and not sinuate; shallowly punctato-striate, the intervals almost plane, a little broader than the striae and each with a single row of small, widely spaced granules, each bearing a short curved white seta. *Legs*: with fairly dense grey white scaling, femora without a tooth. *Genitalia*: Male with aedeagus strongly pointed at the apex. Female with spermathecal gland enlarged so that the spermatheca is more or less Y-shaped, spermathecal duct is long and coiled.

Body length: 6.5 - 7.0 mm.
Sexual dimorphism: None obvious

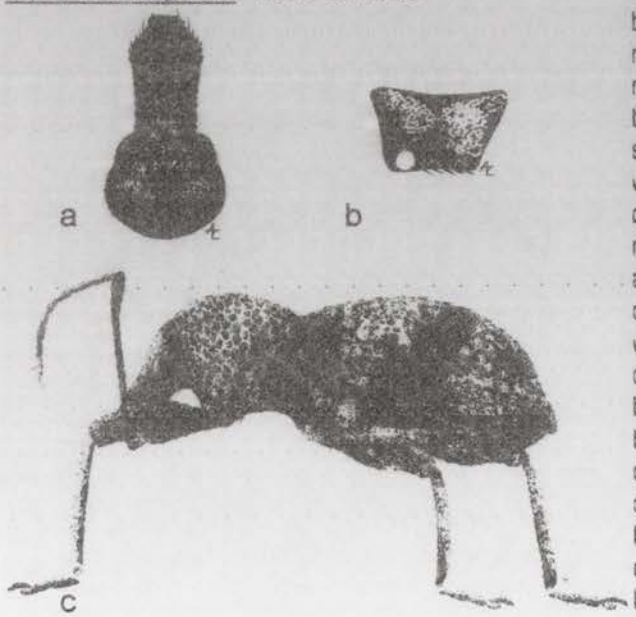

Figure 4. *Oribius improvidus* Marshall: (a) Habitus lateral view; (b) Head, dorsal view; (c) detail of mesepimeron and metepimeron, lateral view.

Oribius inimicus Marshall, 1957 (Fig. 5)
Oribius hostis Marshall 1957

Type: Cotype (male and female *in copula* on *Coffea arabica* - male above and female below), Minji, 24/ 11/ 1954, R. S Carne, ex Coll. Dept. Agri., Pt. Moresby, NH. 119. Deposited at the British Museum of Natural History (BMNH), London.

Diagnosis: Male & Female. Derm rather dull black, prothorax without markings, but sometimes with sparse minute pale scales towards the base and on the pleurae; elytra with an ill defined stripe of small round non-contiguous pale scales on interval 5 from the base to near apex, without any sutural stripe but sometimes with an indefinite spot on the suture at the top of declivity which occasionally expands laterally to join the distal stripe on each side; the lateral margin with an abbreviated indefinite pale stripe at about the middle or behind it; the underside with a patch of dense white scales at the sides of the mesepimeron and metepimeron; prothoracic and mesothoracic processes without white squamate scales but both with long soft pale erect setae. *Head*: with the vertex opaque, finely rugulose, the frons coarsely punctate, with a short median sulcus; the eyes gently convex. *Rostrum*: as long as broad, gradually widening from the base of the genae; the median dorsal area coarsely punctate with a shallow abbreviated median sulcus, and no elevation at the top of the declivity. *Antennae*: long and slender, red-brown, joint 2 of the funnicle slightly longer than 1. *Prothorax*: in male strongly rounded laterally, widest at or rather beyond the middle, slightly broader than long, the feebly arcuate apical margin narrower than the base, which is truncate carinate margin; dorsum moderately convex longitudinally, with dense small rounded granules that are not all flattened towards the sides and base, but become much sparser and smaller on the pluerae, the dorsal granules each with a very short recumbent white seta; prothorax of the female somewhat narrower and less rounded. *Elytra*: similar to *O. destructor* but less acuminate apically in both sexes, with the granules on the intervals smaller and less conspicuous, and without any white sutural stripe; the apex produced downwards like a beak in the female. *Legs*: red-brown, with sparse subrecumbent white setae; the tibiae of the male without fringes; the front tibiae distinctively denticulate in both sexes, and those of the male not incurved at the apex; the hind femora very slightly exceeding the apex of the elytra. *Genitalia*: Male with apex of aedeagus broadly rounded. Female with spermathecal gland enlarged so that spermatheca is more or less Y-shaped, spermathecal duct short and straight.

Body length: 5.0 - 6.0 mm.
Sexual dimorphism: Male body stout and short; hind femur reaching apex; hairy on meso- and meta-thorax ventrally; meso- and meta-sterna depressed. Female body narrow and elongate; hind femur not reaching apex; not hairy on the meso- and meta-thorax ventrally; meso- and meta-sterna not depressed.

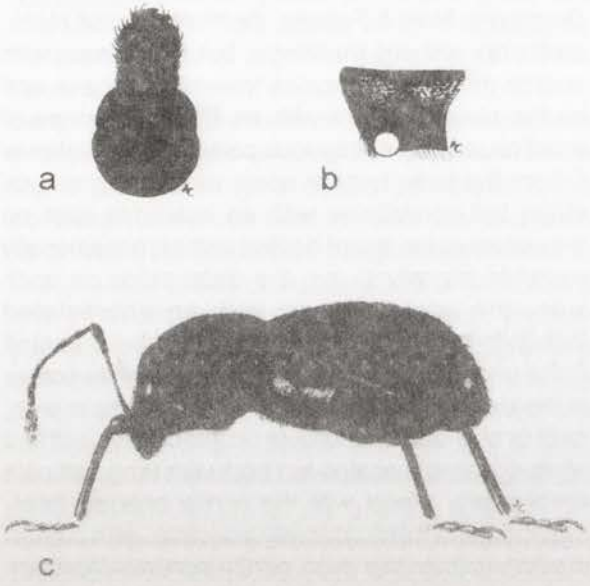

Figure 5. *Oribius inimicus* Marshall: (a) Habitus lateral view; (b) Head, dorsal view; (c) detail of mesepimeron and metepimeron, lateral view.

Oribius* sp. nr. *leucopleurus (Faust, 1897) (Fig. 6)
Type: No type material

Diagnosis: Male and female, derm black to light brown with scattered stripes of white squamate scales that are sometimes easily abraded. Patch of white elongate squamate scales extending full length of rostrum (between eyes to behind abrupt declivity). Prothorax shiny black and without scales. Elytra with stripe of white squamate scales on intervals 5 and 6 extending half way from base and spreading outwards at base; band of white squamate scales at top of declivity extending from interval 3 to interval 7 and broadening outwards at declivity; stripe on interval 10 extending from below hind legs to apex spreading inwards thereby; mesepimeron without or rarely with scales; contiguous patch of white elongate decumbent squamate scales on metepimeron; prothoracic and mesothoracic processes with white decumbent setae. *Head*: separated from rostrum by deep angulate sulcus between eyes; with less pronounced incomplete carinae behind eyes on frons; dorsum moderately convex; eyes almost elongate. *Rostrum*: parallel sided slightly longer than broad; very pronounced patches of subcumbent scale on parallel sides; dorsum carinate; emerginate prior to abrupt apical declivity. *Antennae*: scape slender, cylindrical and elongate widening at apex; funnicle with segment 2 longer than segment 3 but about same as segment 1. *Prothorax*: about as long as broad at widest width; widest above forelegs; moderately round laterally; truncate at base and as wide as apex; with fine erect setae; dorsum moderately convex. *Elytra*: ovate, sub-compressed behind; dorsum moderately convex at mid-region; striae not granulate but with short erect setae on each puncture; intervals about as wide as striae. *Legs*: brownish with shiny femora, subcumbent dense setae on all pairs of legs- less pronounced on femora; dense patch of whitish setae on the inside of coxae of fore and mid legs. *Genitalia*: Male with apex of aedeagus broadly rounded. Female with spermathecal gland not enlarged and spermathecal duct short and straight.

Body length: 6-7 mm.
Sexual dimorphism: Male hind body generally narrow; meso- and meta-sterna depressed; two basal sterna narrow and depressed. Female hind body broad; meso- and meta-sterna not depressed; two basal sterna broad and slightly convex.

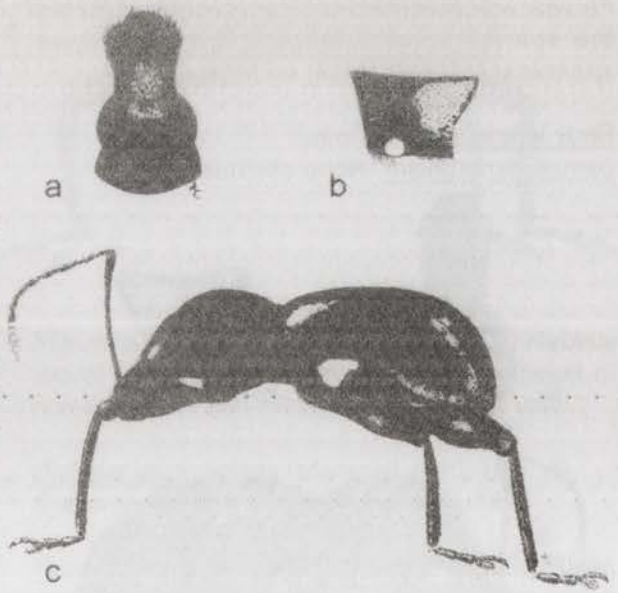

Figure 6. *Oribius* sp. nr *leucopleurus* (Faust): (a) Habitus lateral view; (b) Head, dorsal view; (c) detail of mesepimeron and metepimeron, lateral view.

***Oribius* sp.1.** (fig. 7)

Type: No type material.

Diagnosis: Male and female, derm black all over with low circular white squamate scales scattered all over the body without forming distinct patterns, more patchy on prothorax; scales inconspicuous to naked eyes; mesepimeron and metepimeron with non-contiguous white circular squamate scales; prothoracic process devoid of scales and setae; mesothoracic process with elonagte almost needle like white suberect setae. *Head*: separated from rostrum by deep angulate sulcus between each eye; dorsum moderate to rarely convex; eyes globular and strongly convex; with short squamate scales. *Rostrum*: parallel sided and longer than broad; dorsum with deep sulcus extending entire length; with scattered circular white squamate scales and decumbent setae; with elevation prior to abrupt apical declivity. *Antennae*: scape slightly thicker, cylindrical and gradually widening at apex; funnicle with segment 2 longer than other segments but slightly longer or almost about same as segment 1; elongate, suberect setae on all segments. *Prothorax*: about as long as wide at broadest width; dorsum strongly convex; truncate at base and there wider than apex; granules less pronounced with intermediate punctures having short decumbent setae. *Elytra*: ovate, subcompressed behind; dorsum strongly convex at mid region; striae granulate with suberect setae on each granule; intervals narrow. *Legs*: scattered circular white squamate scales on all femoral and tibial segments; dense elongate setae on tibial and tarsal segments. *Genitalia*: Male with apex of aedeagus not pointed (slightly rounded). Female spermathecal gland not enlarged, spermathecal duct very long and coiled.

Body length: 7-8 mm.
Sexual dimorphism: None obvious

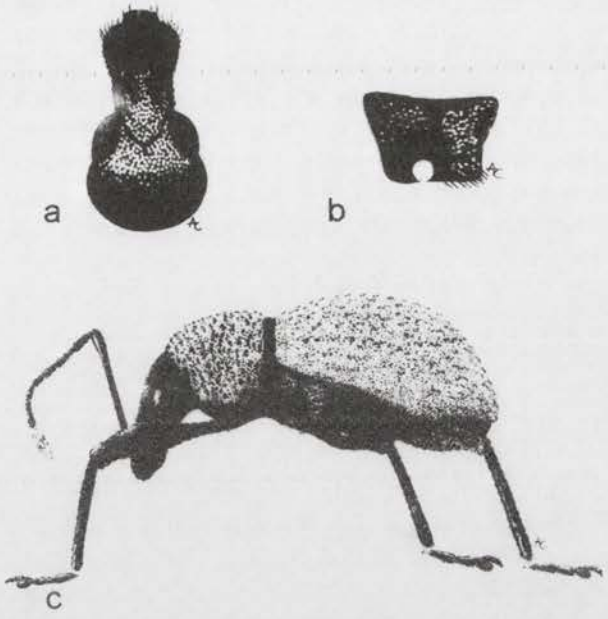

Figure 7. *Oribius* sp.1: (a) Habitus lateral view; (b) Head, dorsal view; (c) detail of mesepimeron and metepimeron, lateral view.

DISCUSSION

For the seven species keyed here, only the holotype specimens of *O. destructor* and *O. inimicus* have been viewed. The other four species (*O. cinereus*, *O. cruciatus*, *O. improvidus* and *Oribius* sp. nr *leucopleurus*) are identified from literature descriptions and confirmed reference material held at the National Agricultural Insect Collection (NAIC) in Kila Kila, Port Moresby. Attempts to confirm *Oribius* sp. nr *leucopleurus* as *O. leucopleurus* (Faust) were unsuccessful due to the unavailability of type material. Thus the species is retained as *species near leucopleurus* in this paper. The species regarded as a new species could be a named species; however, due to the unavailability of type material and inadequate original descriptions, a full generic revision would be needed to confirm its correct status.

In general appearance, *O. destructor* is similar to *O. inimicus* and the species co-occur. However, the latter species is much smaller in size, with white contiguous squamate scales present on the mesepimeron and the metepimeron. The former species is larger and has only few scattered white scales on the metepimeron, which is absent on the mesepimeron. Both species are widely distributed at higher altitudes (though the altitudinal ranges are not fully known) and are the common pest species on wide range of crops. *Oribius* sp. nr *leucopleurus* and *Oribius* sp.1 are also restricted at higher altitudes, but are not as common as *O. destructor* and *O. inimicus*. *Oribius* sp.1 is more common on citrus, attacking both the leaves and the fruits (authors' unpublished data). *Oribius cinereus*, *O. cruciatus* and *O. improvidus* are restricted to the lowland areas of the mainland and are also serious pests of wide range of crops.

ACKNOWLEDGEMENTS

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ANALYSES OF BIRTH WEIGHT OF CROSSBRED LAMBS AT MENIFO, PAPUA NEW GUINEA

Gariba Danbaro[1], Siva Sivasupiramaniam[2] and Anton Benjamin[2]

ABSTRACT

Birth weight of lambs from Priangan x Corriedale F1, Priangan x Perendale F1 and F1 x F1 (or Halfbred) ewes born between 1994 and 1998 at the Menifo Sheep Research Station in the Eastern Highland Province of Papua New Guinea were analyzed. The fixed effects linear model used included ewe genotype, sex, birth type, years and year by birth type interaction. All effects in the model contributed significantly to variation in birth weight of lambs. Least squares mean birth weight of lambs from Halfbred, Corriedale and Perendale ewes were 3.32 ± 0.04 kg, 3.18 ± 0.05 kg and 2.79 ± 0.07 kg respectively. The significantly higher birth weight of lambs from Halfbred (F1) ewes suggests maternal heterosis may be an important factor affecting birth weight of lambs.

Key words. *Crossbreeding, growth, sheep, breeds, Papua New Guinea, Corriedale, Perendale, Highlands Halbred.*

INTRODUCTION

The sheep crossbreeding programme at Menifo in the Eastern Highlands Province of Papua New Guinea, started in 1982, came to an end in the late 1990s but the data gathered during the period still provides useful information for studying various aspects of sheep production in Papua New Guinea. Crossbreeding of locally adapted sheep breeds to genetically improved temperate breeds has often been proposed as a tool for faster genetic improvement of sheep in the tropics. The purpose of such crossbreeding programs is usually to produce an intermediate breed, which can survive, exhibit heterosis for the economically important traits and also express desirable characteristics of both breeds, that is, breed complementarity. The Menifo sheep research station concentrated on producing the Highlands Halfbreds (HHF) by mating crossbred rams and ewes which result from crossing Priangan (PR) rams with purebred Corriedale (CORR) and Perendale (PER) ewes imported from New Zealand. The halfbreds produced from these types of mating were subsequently distributed as breeders to smallholder farmers.

PR is a locally adapted coarse-woolled sheep, which is recognized as a prolific breed (Mason 1980). CORR is a dual-purpose breed (wool and mutton) originating from New Zealand (Maijala 1997). PER also originated from New Zealand where it is used for meat and medium wool production in difficult hill country (Mason 1996).

Since the inception of the crossbreeding program at Menifo some reports have been published on different aspects of productivity of the F1s and halfbreds, using parts of the data collected. Manua and Malik (1988) found that overall lambing and weaning percentages were 71% and 37% respectively in 1984 compared to 87% and 65% respectively in 1985 and attributed the difference to influences such as rainfall, forage availability, change in mating systems and flock management. However no comprehensive studies have been conducted to compare the performance of the different crossbred genotypes with respect to birth weights of lambs at the station. Birth weight of lambs is an important trait, which, especially in severe environments, affects lamb survival (Alexander 1984) and has positive medium to high genetic correlations with other growth traits such as weight at weaning and at older ages (Fogarty 1995), which in turn affect profitability of meat sheep operations. Lamb birth weight is influenced by a number of factors including ewe and ram genotype, ewe nutrition, season of birth, sex of lamb, and litter size (Martin *et al.* 1980).

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The main objective of this report is therefore to estimate and compare the birth weight of lambs of the different ewe genotypes born between 1994 and 1998 and estimate phenotypic trends in this trait over the period, taking into account sex and birth type of lambs.

MATERIALS AND METHODS

Menifo sheep research station is located 6° 15'S, 145° 30' E and 1405 metres above sea level, about 15km from Goroka, capital of the Eastern Highlands Province of Papua New Guinea. The area experiences a humid tropical type climate with average annual rainfall of 1285 mm, with most of it falling between October and April. Mean annual temperature and relative humidity range between 19.6°C to 27.3°C and 65% to 81% respectively (Sivasupiramaniam *et al.* 1986).

All classes of animals at the station were rotationally grazed but lactating ewes, weaners and hoggets were separated from the breeding group. Pastures consisted of both native species (e.g. *Imperata cylindrica*, *Themeda australis* and *Panicum maximum*) and introduced improved species (e.g. *Stylosanthes spp.*, *Macroptilium spp*, *Desmodium spp.*, *Trifolium repens* Haifa, *Neonotonia wightii* Copper, *Pennisetum clandestinum* and *Setaria spp*). Mineralized salt licks and water were provided at all times. Seasonal mating once a year was practiced using PR rams on CORR and PER ewes and HHB rams on HHB ewes. During the breeding season a ratio of 15 to 20 rams to about 500 ewes was maintained. After six weeks rams were withdrawn and both groups kept together until the next mating season. Ewes were culled against ease of lambing, old age and ailments such as chronic foot scald problems. HHB ram lambs and replacement ewes were selected from ewes with multiple births and on weaning weight basis. Sheep of all ages were identified by ear tags and were drenched to control gastrointestinal parasites regularly. Tail docking of lambs was practiced at 3 weeks of age followed by weaning at 3 months of age. Birth weight, dam number, date of birth, sex, and birth type were recorded on all lambs born at the station between 1994 and 1998 and were used in this study.

Least squares analysis of variance was carried out on 1108 lamb birth weight records in this study. The fitted fixed effects linear model, in statistical notation was:

$$Y_{ijkl} = G_i + B_j + S_k + T_l + BT_{jl} + e_{ijkl}$$

Where: Y_{ijkl} was a birth weight observation;

G_i was ewe genotype (i = 1, ,3 i.e. HHF, CORR and PER)

B_j was the lamb birth type (j = 1,2 i.e. single and twins)

S_k was the sex of the lamb (k = 1,2 i.e. males and female)

T_l was year of birth of lamb (l = 1, ,5 i.e. 1994 - 1998)

BT_{jl} was birth type by year interaction.

e_{ijkl} was a random residual term assumed normally and independently distributed with zero mean and unit variance. The analysis was run in the GLM procedures of SAS (2001). Preliminary runs included season of birth of lambs, parity and other two-way interactions between the main factors but these did not contribute significantly to variation in birth weight and were therefore removed from the final model. Less than 1% of births were triplets. This subclass created a very unbalanced design, which affected estimates of least squares means and was therefore also removed from the final analysis.

RESULTS AND DISCUSSION

Table 1 shows the results of the analysis of variance of birth weight of the crossbred lambs.

Table 1. Least squares analysis of variance of birth weight of crossbred lambs.

Source	Degrees of freedom	Sum of Squares	F value	Pr > F
Model	12	78.50	15.21	<0.0001
Error	1095	471.07		
Corrected total	1107	549.57		
Birth type	1	33.34	77.51	<0.0001
Sex	1	2.06	4.78	0.0290
Ewe genotype	2	19.97	22.76	<0.0001
Year	4	18.97	11.03	<0.0001
Birth type by Year	4	10.98	6.38	<0.0001

The model fitted to birth weight observations was highly significant (P<0.0001).

Least squares Mean birth weights of the different categories of lambs are shown in Table 2. Ewe genotype significantly contributed to variation in birth weight of lambs at the station (P<0.0001). The mean birth weight of lambs born to HHF, CORR and PER ewes were 3.29 kg, 3.11 kg and 2.73 kg respectively.

The differences in lamb birth weight for these three categories of lambs were significant. The higher birth weight of lambs of HHB ewes may be partly attributed to the ewe's better adaptation to the less favourable pasture and health conditions that prevailed in most part of the study period as described later. Another possible reason for the higher birth weights of lambs from HHF ewes could be that they were relatively younger due to regular replacement policy compared to CORR and PER ewes which were imported and not replaced by younger ewes. The higher birth weight of lambs of HHB ewes also suggests that maternal heterosis for birthweight may be important.

Maternal effects are known to significantly influence preweaning traits in lambs (Maria et. al. 1993; Nasholm and Danell 1994). The mature weight of CORR is higher than that of PER therefore, given the same ram breed (i.e. PR), birth weight of their lambs would be expected to follow the same trend as their mature weight as was observed in this data. Even though birth weights are known to affect lamb survival (Alexander 1984), it is not possible to quantitatively estimate this effect in this study due to lack of appropriate data.

Other environmental factors, which contributed significantly to variation in birth weight of lambs on the station were birth type (P<0.0001), sex of lamb (P<0.029) and year of birth (P<0.0001) (Table 1). The mean birth weight of single and twin born lambs were 3.32 kg and 2.77 kg respectively (Table 2). Donald and Russell (1970) estimated the mean birth weight of twins to be 80% of that of single born lambs which is close to the 83% estimated in this data. The lower birth weight of twins is often attributed to competition for maternal resources in the prenatal period (Alexander 1984).

Table 2. Mean birth weight of crossbred lambs.

Factor	Subclass	Number of Observations	Means ± standard error (kg)
Birth type	Single	917	3.32 ± 0.03
	Twin	191	2.77 ± 0.06
Sex	Male	532	3.09 ± 0.04
	Female	576	2.99 ± 0.04
Ewe genotype	Crossbred	663	3.29 ± 0.04
	Corriedale	318	3.11 ± 0.05
	Perendale	127	2.73 ±0.07
Year	1994	72	3.59 ± 0.09
	1995	203	2.95 ± 0.08
	1996	266	2.99 ± 0.08
	1997	355	2.88 ± 0.06
	1998	212	2.80 ± 0.06
Birth type by year interaction	Single, 1994	46	3.78 ± 0.10
	Single, 1995	183	3.53 ± 0.05
	Single, 1996	244	3.26 ± 0.05
	Single, 1997	306	3.06 ± 0.04
	Single, 1998	138	2.94 ± 0.07
	Twins, 1994	26	3.40 ± 0.14
	Twins, 1995	20	2.36 ± 0.15
	Twins, 1996	22	2.73 ± 0.15
	Twins, 1997	49	2.70 ± 0.10
	Twins, 1998	74	2.66 ±0.09

The mean birth weight of males and females were 3.09 kg and 2.99 kg respectively. Male lambs are usually 5% to 12% heavier than female lambs at birth (Alexander 1984; Robinson *et al.* 1977).

Mean birth weights of lambs generally declined over the years from 1994 to 1998 but the mean birth weight in 1994 is larger in comparison to those of the later years. According to Low and Low (2000) critical external funding for the project was stopped in 1996. Pasture conditions (quantity and quality) declined from 1995 onwards as paddocks were not slashed or fertilized as in the past due to funding constraints. For the same reason ewes were not treated for gastro-intestinal parasites regularly from 1995 as compared with the past, the average age of breeding ewes increased due to irregular replacement and law and order problems accounted for loss of some productive breeding stock. These factors could therefore possibly account for the generally decreasing birth weights of lambs starting from 1995.

Mean birth weights for the year by birth type interaction categories show that birth weight of lambs born either as single or twin appear to follow the same trends over the years as overall birth weights for each year. The yearly trend in birth weight for single and twin-born lambs could therefore also be explained by the same factors mentioned above which affected overall yearly trends in mean birth weight of lambs.

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IMPACT ASSESSMENT OF THREE IMPROVED TARO (*COLOCASIA ESCULENTA*) VARIETIES IN THE MOROBE PROVINCE, PAPUA NEW GUINEA.

Joe Guaf and B.Komolong

ABSTRACT

In 2001, the National Agricultural Research Institute released three new taro varieties from its taro breeding programme. The breeding programme was funded by AusAID under the TaroGen project. Since the release, a considerable amount of planting material has been distributed to farmers. To capture the impact of the new technology, an impact assessment survey was conducted in the Morobe province to estimate how the target beneficiaries, their households and communities will benefit in the longer term as a result of these taro varieties and to identify drawbacks of the released material for further research if needed. Apart from the TLB resistance and high yielding characteristics of these varieties, the farmers interviewed found the taro varieties to have impressive plant growth characteristics which are of importance and play a major role in production of the crop. The varieties have shown outstanding performance in farmer fields as compared to local varieties. This gives significant importance to these new varieties for improved food supply and diets of the people and, alternatively, promising varieties for income generation.

Keywords: *Taro varieties, breeding programme, impact assessment survey, Morobe Province, TBL resistance, farmers fields.*

INTRODUCTION

Taro (*Colocasia esculenta* (L.) Schott), a member of the Araceae family, is an ancient crop grown throughout the humid tropics for its edible corms and leaves. The crop is also closely associated with local culture and tradition. In Papua New Guinea (PNG) the crop has retained supreme importance in the diets of the inhabitants. Quantitatively it remains the fourth most important food crop (Bourke and Vlassak 2004) and many people depend heavily upon it as a staple food.

The past few decades have seen major changes in the farming systems of PNG. Increase in insect pest and disease levels and anthropogenic activities have contributed to the loss of genetic diversity and the consequent deleterious replacement of traditional taro varieties by other crop species. In order to ensure sustainability of taro production and grower confidence in the crop, the National Agricultural Research Institute (NARI) established a taro breeding programme (Okpul *et al.* 1997). One of the major aims of the programme was to address taro leaf blight (TLB) disease, caused by the fungal pathogen *Phythophtora colocasiae*. Agronomic traits of importance such as yield, and good eating quality, were other considerations along with consistent performance of these characteristics in varied agro-ecological conditions throughout PNG. The system of breeding using recurrent selection was adopted in which breeding populations undergo sequential crossing followed by progeny evaluation and selection in a series of Cycles prior to recommendation and release of new varieties. One cycle generally takes approximately two years but this may vary between 18 and 24 months depending on the situation during the cyclic period (Okpul and Ivancic 1996). Using this breeding approach, NARI released three new taro varieties designated NT (NARI Taro) 1, 2 and 3 from breeding Cycle 2 in 2001. Selection and recommendation was based on TLB resistance, improved yield and eating quality and, more importantly, a trend of consistent performance of these traits across tested environments. Since the release, a considerable amount of planting material has been distributed to farmers directly by the institute, through the extension services and by non-government organizations. This study was aimed at assessing the impact of the improved varieties on farmers in the Morobe province.

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OBJECTIVES

The major objectives of this study were to:

- v provide an estimate of how the target beneficiaries, their households and communities in the Morobe province will benefit in the longer term as a result of adopting these varieties;
- v give an opportunity to identify drawbacks in the released material, if any, and redefine the selection criteria if necessary; and
- v provide an opportunity for rationalization of resources for further research in this area.

METHODOLOGY

Survey questionnaires were formulated based on simple direct questions offering multiple choices related to eight major areas: farmer information, location information, farm or farmer information related to taro production, acquisition, multiplication and distribution of NARI taros, adaptation and performance of the new varieties, level of adoption, impact on livelihoods and future work needed.

The selection of survey sites (Appendix) was based on the status of taro in the farming systems of the rural people of Morobe, where taro is a dominant or sub-dominant staple, and on distribution records of planting materials of the improved NT varieties. Five districts (Finschhafen, Huon Gulf, Markham, Nawaeb and Tewae-Siassi) were identified for the survey. In each of the five districts, three villages were chosen as major survey areas and ten sample farmers were chosen from each area for interview. This gave a total of thirty interviewees in each of the five districts and 150 samples overall. Groups of three to four interviewers were formed and assigned to survey sites in each district over a period of four weeks.

RESULTS AND DISCUSSIONS

Farmer Information

The numbers of men and women who participated in the survey are represented in Figure 1. Male

Table 1. Impact assessment survey sites in five districts of Morobe province

Village	District	Altitude (masl)	Annual rainfall (mm)
Kamlawa	Finschhafen	<40	4000-5000
Katika	Finschhafen	<40	4000-5000
Heldsbach	Finschhafen	<300	4000-5000
Musom Tale	Nawaeb	<40	4000-5000
Tikeleng	Nawaeb	<40	4000-5000
Morobe Coast	Huon Gulf	<40	3000-4000
Hobu	Nawaeb	200-600	3000-4000
Muru	Tewae-Siassi	<40	3000-4000
Izon	Tewae-Siassi	<40	3000-4000
Yaga	Tewae-Siassi	<40	3000-4000
Pusika	Huon Gulf	<80	2000-3000
Arifiran	Markham	200-400	2000-3000
Mutzing	Markham	200-400	2000-3000
Ragiampun	Markham	200-400	2000-3000
Noa	Huon Gulf	100-200	1000-2000

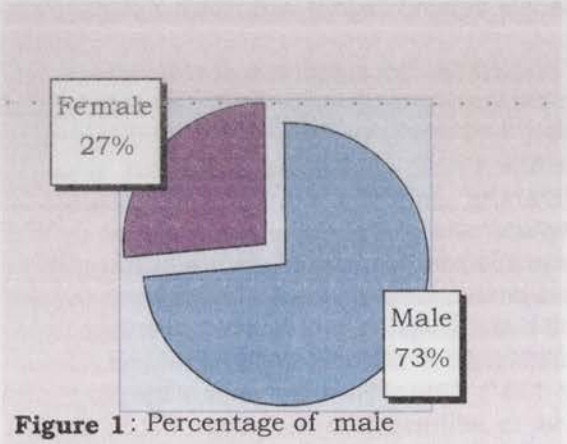


Figure 1: Percentage of male and female participants in the survey.

farmers, mostly aged between 30-45 years, dominated with nearly three-quarters of the sample population. This gave an indication that men of the older age group are actively involved in such organized activity in rural areas.

Household size of the farmers varied greatly from less than five to 15 family members. However, most families were in the range of 5-10 persons as observed in all five districts.

Depending on the household, farming land varied between families and from district to district. Nevertheless, a significant number of people cultivate land areas between 0.5 and one hectare.

Food Crops Grown by Farmers

The crops grown for own consumption include aibika *(Abelmoschus manihot)*, banana, cassava, *Xanthosoma* taro, maize, peanut, pitpit (*Saccharum edule*), rice, sweet potato, *Colocasia* taro, greater yam (*Dioscorea alata)* mami (*D. esculenta),* african yam (*D.rotundata*) and various vegetables. However, the dominant staple crops said to be grown were african yam, banana, cassava, mami, sweet potato and taro. In general, most people in all districts highly preferred banana while other staple crops, including taro, remain secondary in their diets.

For income generation, a significant number of people indicated vegetable production as a major enterprise for cash income, apart from semi-commercial crops such as betel nut and its associated mustard plus vanilla which has become popular in recent times due to its good market price.

Farmer Information Related to Taro

Farmer land under taro production ranged between less than 0.5 to one hectare (Figure 2) in all districts, but the majority of farmers cultivate taro on less than 0.25 ha of land. The produce from their land gives a good yield with most corm sizes between medium and large. The number of taro varieties owned by farmers varied between five and 15 cultivars. However, the highest percentage (49.7%) of the population responded as having at least five taro cultivars.

Farmers have various reasons for maintaining taro varieties. However, eating quality is the major characteristic on which selection of taro varieties is based. Presence of taro leaf blight (TLB) was mentioned as a common problem in the taro gardens, while virus diseases such as Alomae and Bobone Virus Complex (ABVC), Dasheen Mosaic Virus (DsMV) and Taro Vein Chlorosis Virus (TVCV) were regarded as minor diseases causing

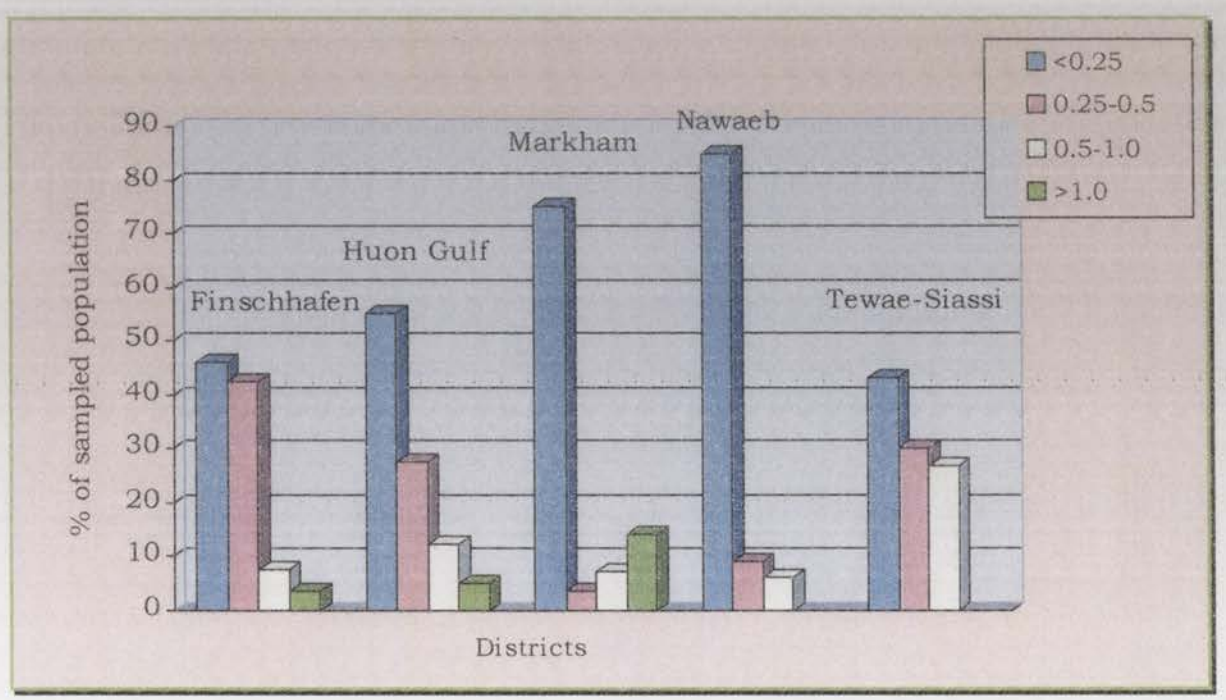


Figure 2: Farmer land under taro production in the five districts

less significant crop losses. On the other hand, taro beetle (*Papuana sp.*) is a major pest problem in all areas, causing more than fifty per cent of crop losses (Figure 3).

multiplication of NT planting material. However, farmers commented that improved NT varieties have sufficient suckering ability (5-7 suckers) in their gardens. The results gave very little indication of wider distribution of NT planting materials in all five districts and it was found that most farmers

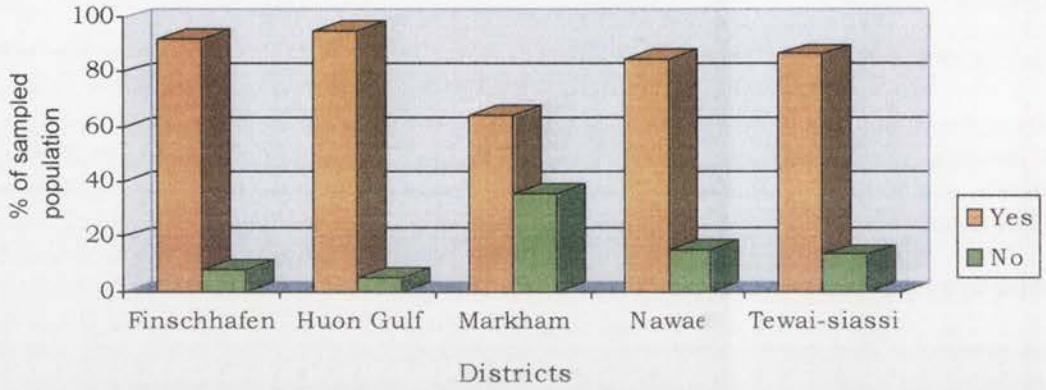


Figure 3: Farmer indication of taro beetle problem in respective districts.

Acquisition, Multiplication and Distribution of NARI Taro

Farmers indicated that most planting materials of NT varieties were obtained through extension providers in their area, while other means such as from the Morobe provincial shows and NARI open days remain restricted as there is minimal chance of getting into town for such activities. Farmers mentioned that the materials have been delivered to them without cost.

The use of suckers and the mini-sett technique were identified as common for farmers in

did not further distribute planting material to other farmers.

Performance and Adaptation of NTs

It was clear that overall, the NT varieties have better performance with outstanding growth rate and plant vigour (Figure 5) in comparison to the local taro varieties. More importantly, farmers are impressed with NT varieties for their TLB resistance. TLB incidence in the fields was rarely seen and plants remain healthy and absolutely clean. Only rare cases (Figure 6) of viral diseases such as Alomae and Bobone Virus Complex

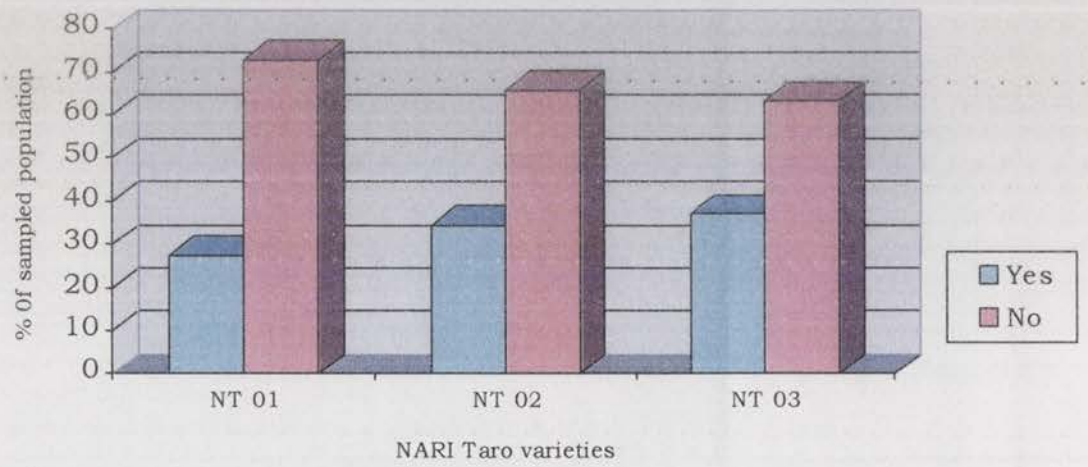
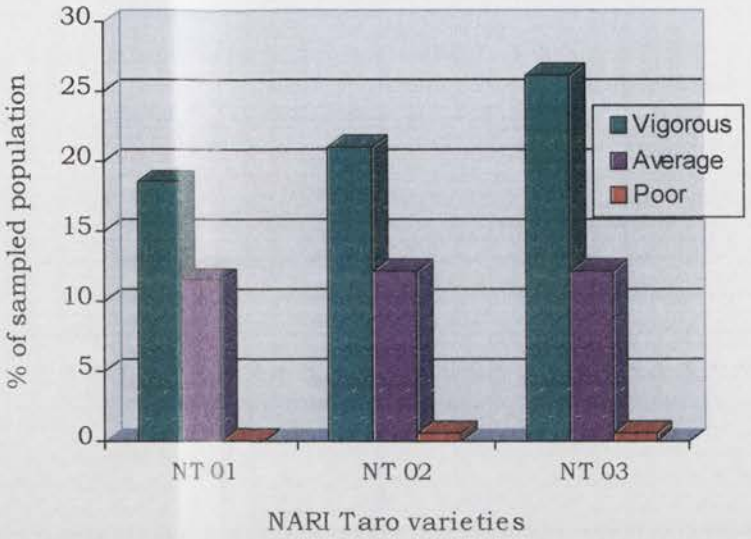


Figure 4: Planting materials of the three NT varieties in farmer fields

Figure 5: Plan growth performance of each of the three NT varieties



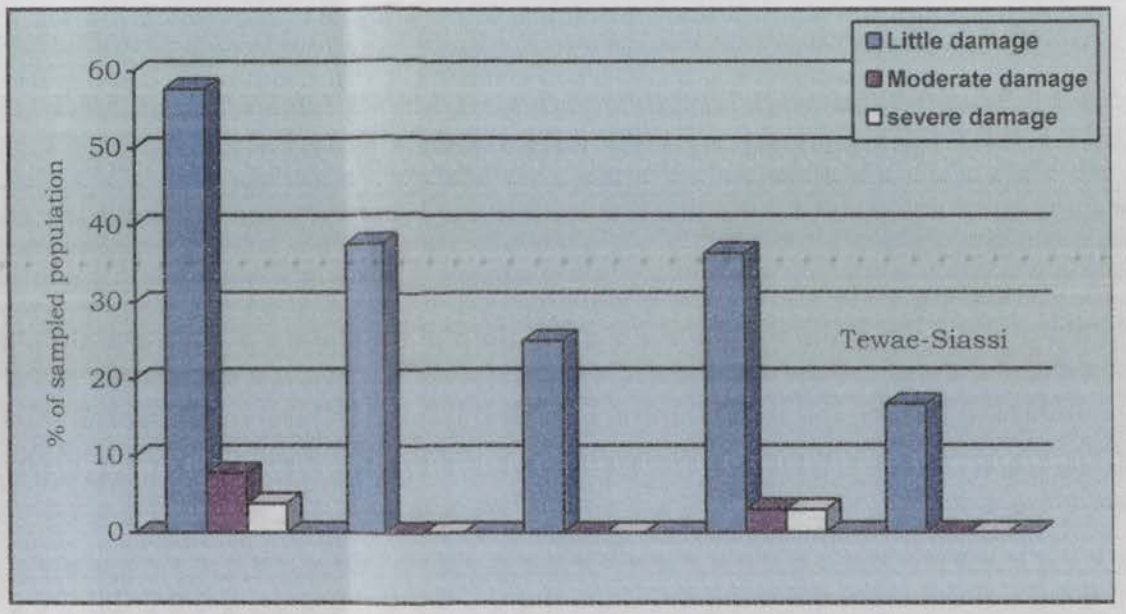


Figure 6: Effect of viral diseases in each of the five districts

(ABVC) were reported to affect the improved taro varieties.

Adoption of NTs

With respect to adoption of NT varieties, the sample population showed positive responses. Most people are satisfied with their performance and continuity of growing the new varieties is undisturbed. Farmers indicated that NT varieties are better in terms of withstanding TLB disease and production in their garden yields larger corm sizes in comparison to the local varieties. Despite this, it was observed that there is insufficient supply of planting material, especially in the Huon Gulf, Markham and Tewae-Siassi districts (Figure 7). Farmers who initially obtained the varieties retained very little of what they received and, as a result, this has restricted further distribution of planting materials. This indicates behavioral

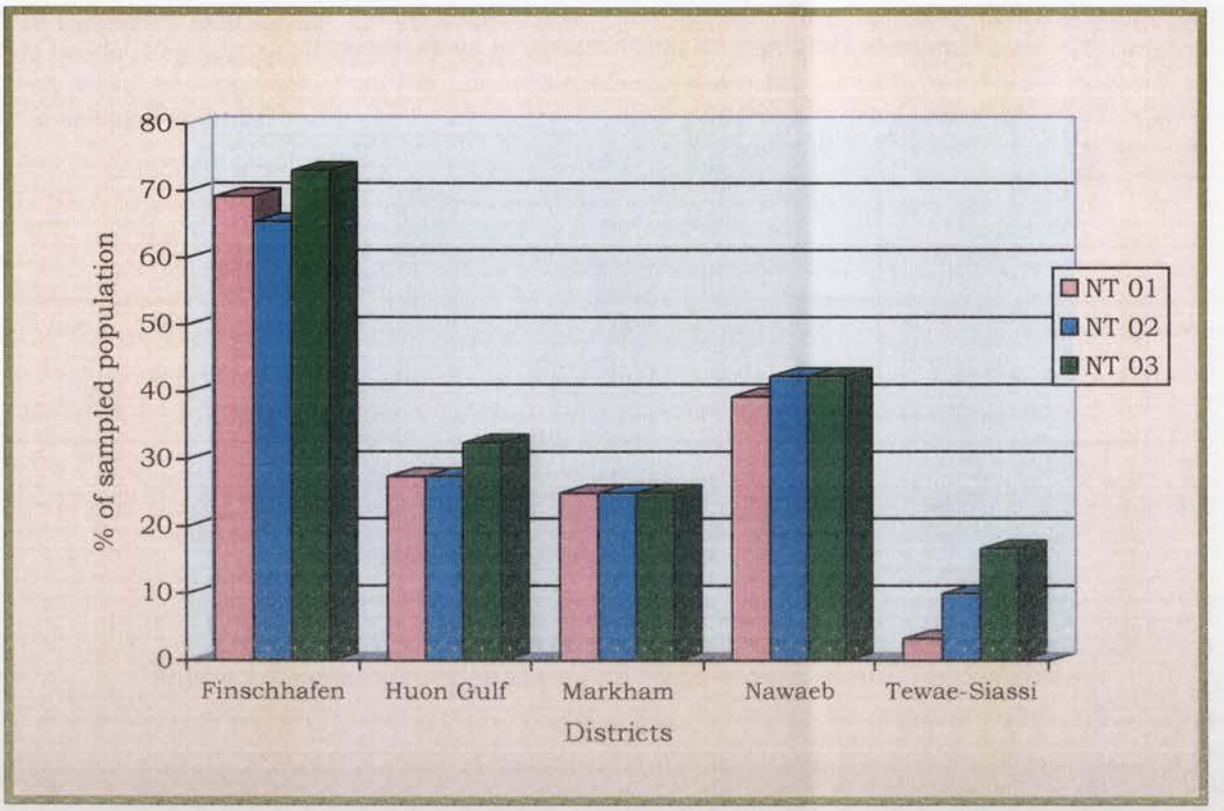


Figure 7: Estimated occurrence and proportions of NT varieties in farmer fields in each of the five districts

attitudes that many subsistence gardeners in PNG have in maintaining genetic resources.

Impact on Livelihoods

In general, the most appropriate uses of traditional taro varieties were indicated by farmers as for self-consumption, diversification, cash income and special occasions including bride price ceremonies and feasting. The majority of the population was impressed with the NT varieties because of their improved morphological characteristics such as growth vigour and large corm size. This adds significant importance to these new varieties for improved food supply in the diets of the people (Table 2). The released taro varieties have been in high demand for their usefulness in managing TLB incidence among local cultivated varieties, to the extent of creating buffers against TLB in farmer fields. Moreover, many farmers commented that the new varieties, although not yet reaching many farmers, would contribute significantly towards cultural activities like bride price ceremonies and feasting; when large quantities of taro corms are required. In addition, the new varieties are seen to have advantage in quality over local cultivars with greater potential for alternative enterprise in revenue generation.

Future work

The majority of farmers (93 %) indicated positively their wishes to collaborate with NARI in taro breeding trials and showed interest in receiving new NT varieties. Farmers viewed the most important characteristics of new taro varieties as being high yielding and having good eating quality.

Table 2: Farmer expectations of NTs on the livelihoods of people in the five districts (% of farmers)

Major impact on livelihood	• Districts				
	Finschhafen	Huon Gulf	Markham	Nawaeb	Tewae-Siassi
Improved food supply	84.6	42.5	35.7	30.3	16.7
Income generation	30.8	7.5	17.9	27.3	16.7
Less fertilizer use	0.0	2.5	3.6	3.0	3.3
Less fungicide use	3.8	0.0	0.0	3.0	3.3

For eating quality, characteristics such as stickiness and hard corm texture should be major traits for research since taro preferences are based on these features.

CONCLUSIONS

The impact assessment survey was carried out in five districts of the Morobe province where records have shown distribution of planting materials after the release of NT 01, NT 02 and NT 03 in 2001. During the survey, involvement of farming communities in responding to the questionnaire was dominated by males in every interviewed household. The male participants were, in particular, family heads and, in some cases, older persons in an extended family with an age range of 30-45 years.

Taro, although seen as a dominant crop in these areas, is planted with other staple food crops such as banana, cassava, *Xanthosoma* taro, mami yam, sweet potato and other yams as alternatives in mixed cropping gardening systems. Much of the produce from these staple starchy food crops is retained for self-consumption while very little, usually in small quantities, reaches local market places together with a variety of vegetables for daily cash income needs. Meanwhile, crops such as betel nut, mustard and vanilla play a major role in generating revenue for the household for financing bigger items, which in many instances is being budgeted to meet school fees.

Taro production in farmer fields is small scale, usually taking up to about a quarter of the total land area in the mixed cropping garden. This means that the land under taro is generally less than 0.5 hectares for most farmers. The restriction of farming on a small scale has many practical reasons, the major ones including a high incidence of pests and diseases, lack of marketing opportunity and labour input requirements.

The introduction of NARI released varieties was highly appreciated by many farmers since the new taro lines carry the improved characteristics of resistance to TLB disease and favourable performance in the field. Nevertheless, not enough materials have reached farmers; indicating poor linkages between the research institute and extension providers, and this has resulted in a very narrow distribution of the released technology. This will remain a problem and onward distribution will be limited until adoption becomes more substantial and wide-spread.

RECOMMENDATIONS

The following recommendations are made based on responses of the sampled population with respect to adaptation, adoption and impact of the released NT varieties:

a) Agricultural Policy

Government policies are needed to support research and extension services with more emphasis on root crop subsistence production. Taro plays a major role in food security and determines rural livelihoods in the taro growing areas. Signs of increased land pressure demand improved production techniques. Suggested policies may include considerations of:

a. Household food security
b. Taro marketing at the national level (local and regional markets)
c. Taro as an export product

b) Linkages between Research, Extension and Farmer

The establishment of linkages between the three major parties concerned with technology generation, dissemination and adoption is considered a necessity to allow effective information flows and feed-back, thus making possible desired changes to improve taro production in areas where the crop is known for its popularity.

c) Agricultural Research

The results of the survey show the importance of crop improvement, indicating the necessity for policies and funds to support breeding programmes in other crops, especially considering the crop diversity in PNG and therefore the genetic resources which breeders can work with.

ACKNOWLEDGEMENTS

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go to Jimmy Maro for the map and Trevor Wilson for assistance in data presentation.

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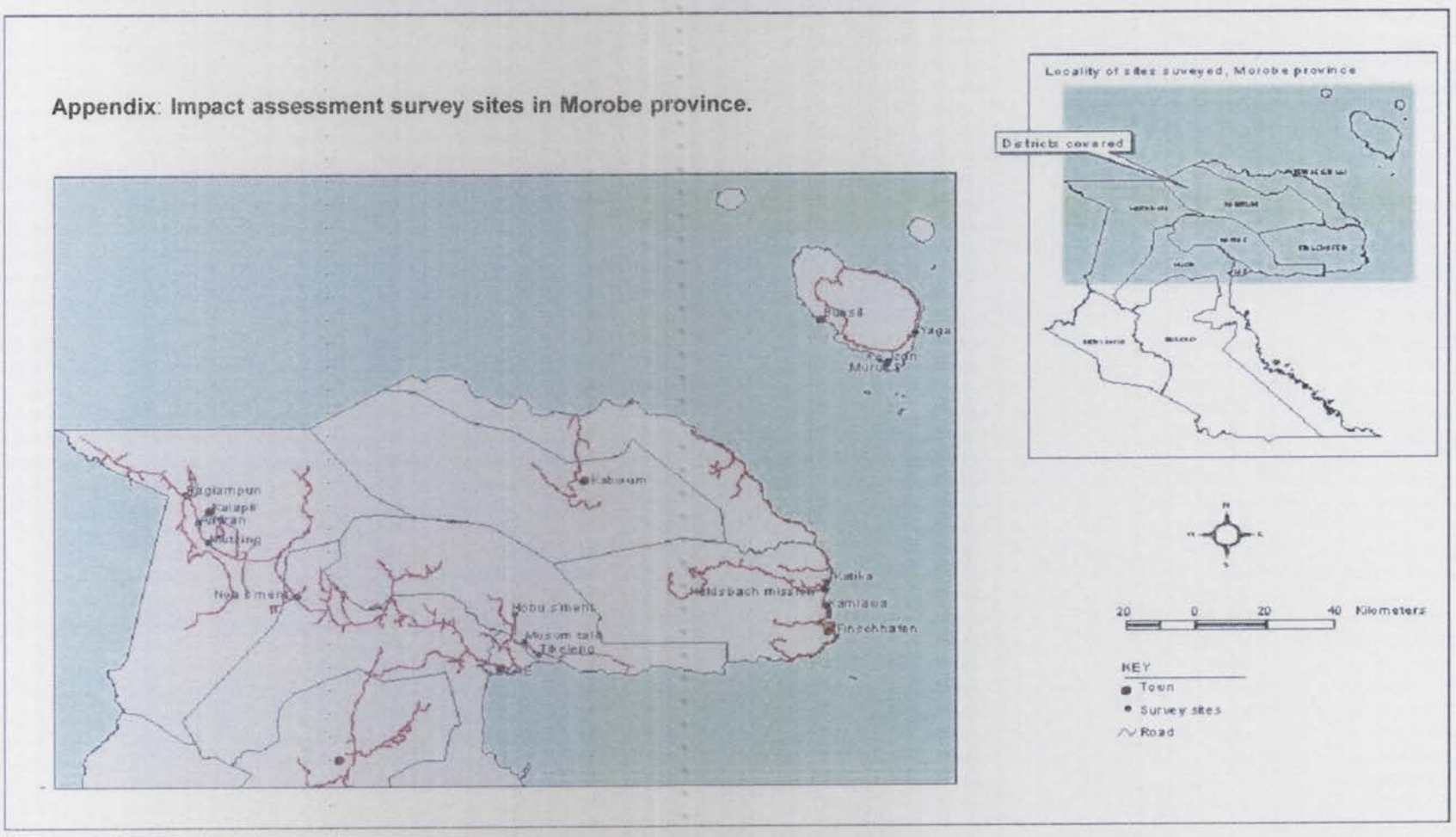
Appendix: Impact assessment survey sites in Morobe province.



Geographical Information System (GIS), National Agricultural Research Institute

FARMERS OPINION ON RICE GROWING IN PAPUA NEW GUINEA

Abdul Halim and William Kerua

ABSTRACT

A survey was conducted in Situm, Markham, and Finschhafen areas of Morobe Province and Kerowagi area of Chimbu Province to assess farmer's opinion on rice growing. Ninety five (95) farmers consisting of both rice and non-rice growers of mixed gender were randomly selected. Using interview schedules data were collected on personal, situational and socio-economical aspects that are likely to influence the farmers' attitude on rice growing.

The study indicated that experienced farmers were able to grow rice as well as other major cash crops successfully. There was a positive relationship between farmers who are members of farmer groups and growing of rice. It was also found that being a member of a farmers association and/or a group have benefited them in some ways. The main reasons for not growing rice by most farmers were, lack of knowledge and skills in rice cultivation, information and access to credit which discouraged farmers from growing rice.

This indicates that adequate rice training is required for farmers to provide them with basic knowledge, skills and techniques in growing rice. Some form of supervised micro financing for growing rice is also essential to enhance rice production in PNG. Intensive extension services with field demonstration of rice cultivation will likely boost rice production. Supply of inputs and milling facilities must also be made available to the community. Interestingly the opinion of the farmers did not differ significantly with locations.

Keywords: *Rice, farmers, opinion, micro-credit, training*

INTRODUCTION

Rice (*Oryza sativa*) was introduced into PNG more that 100 years ago and grown mainly as a subsistence crop in localized area in several parts of the country. Although commercial rice production was promoted in the past, but it was unsuccessful. However, in recent years small scale subsistence rice cultivation has increased substantially. It is now grown throughout PNG, including the highlands.

To date no study has been undertaken to determine the factors that influence subsistence rice production in PNG. Therefore the aim of this study is to determine: (i) the reasons for cultivating rice by subsistence farmers, and (ii) the factors that are influencing subsistence rice cultivation.

METHODOLOGY

Study Design

The design used in this research was 'cross-sectional study design' which is best suited to studies aimed at finding out the prevalence of a phenomenon, situation, problem, attitude or issue, by taking a cross-section of the population in the context of PNG. The research paradigm approach was more 'constructivist' as there is no single explanation that can provide the definitive understanding of a social situation as in a research problem due to multiple reasons why rice can not be cultivated or included in the farming system in PNG. As a constructivist research, more qualitative methods have been used with limited support of quantitative insight.

Population and Sample

A total of 95 farmers 24 each in the Finschhafen, Situm, and Markham area of Morobe Province and 23 in Kerowagi areas of Chimbu Province were randomly selected. The farmers selected were both rice and non-rice growers. Seventy (70) male and 25 female were interviewed. The reason for interviewing non- rice growers was to establish the reasons why they chose not to grow rice. However, data were not analysed according to male or female and that of rice growers and non-rice growers due to small size of the sample.

Department of Agriculture, Unitech

Data Collection and Analysis

The survey was conducted for 2 weeks in November 2005. It was a face-to face personal interview using an interview schedule where most farmers being interviewed in the evenings after their return from garden. Data were analysed using Statistics Packages for the Social Sciences (SPSS) program software. The statistical tests used include percentage distribution, and correlation between independent and dependent variables. These responses were then recorded to obtain correlation coefficient Matrix table to determine the significant relationships. Data were interpreted based on the outcome of the statistical tests.

RESULTS AND DISCUSSIONS

The description of the variables in figures is presented in table 1.

Relationship between Variables

The hypothesis was that an individual's choice of growing rice is a function of personal, situational, and /or socio-economical factors influencing that individual. Correlation analysis was used to test for the existence of a relationship between the growing of rice and the above three factors. The results of bi-variate correlation analysis for selected variables at the four study location are given in Table 2.

Table1. Description of Variables

Variables	Components	Percent (%)
1. Age	< 30 years	22
	30-40 years	34
	> 40 years	44
2. Marital Status	Single	20
	Married	67
	Widowed	8
3. Family size	4 or less	33
	5 - 10	60
	> 10	7
4. Education level	No formal education	7
	Grade 1 – 6	62
	Grade 9 - 12	23
	College level	8
5. Farming experience	Growing rice < 1 year	2
	Growing rice 1-5 years	39
	Growing rice > years	3
	Never grown rice	56
6. Group membership	Farmers group	68
	Non farmers group	32
	Usefulness of group	81
	Group not useful	19
7. Farm size	< 4 hectares	38
	4 – 7 hectares	19
	< 7 hectares	43
8.Cosmopoliteness	Visited other provinces	82
	Never travelled out	18
9. Reasons for growing rice	Self consumption	34
	To sell	1
	Just for trial	10
	For other reasons	3
	Not applicable (non-rice growers)	52
10. Reasons for not growing rice	Lack of knowledge and skills	29
	Lack of rice seeds	7
	Lack of funds	12
	No milling facilities	3
	Lack of extension activities	1
	Not applicable (rice growers)	48

Table 2. Association between rice growing and range of personal, situational, and socio-economical variables

Variables		
Independent Variables	**Dependent Variables**	**r value**
Chimbu		
Age	Reasons for growing rice	ns
Gender	Reasons for growing rice	ns
Marital Status	Reasons for growing rice	ns
Family size	Reasons for growing rice	ns
Education	Maj. cash crops grown	-0.517**
Farm size	Reasons for growing rice	ns
Rice farming experience	Reasons for growing rice	0.594**
Other farming experiences	Maj. cash crops grown	0.447*
Group membership	Group usefulness	0.974**
Cosmopoliteness	Source of extension	-0.503*
Extension visits	Reasons for growing rice	ns
Access to credit	Constraint to grow rice	ns
Markham		
Age	Reasons for growing rice	0.480*
Gender	Reasons for growing rice	ns
Marital Status	Reasons for growing rice	ns
Family size	Reasons for growing new crop	0.490*
Education	Maj. cash crops grown	ns
Farm size	Reasons for growing rice	ns
Rice farming experience	Reasons for growing new crop	ns
Other farming experiences	Maj. cash crops grown	ns
Group membership	Reasons for growing rice	-0.577**
Cosmopoliteness	Access to agric. Information	ns
Extension visits	Reasons for growing rice	ns
Access to credit	Constraint to grow rice	ns
Situm		
Age	Reasons for growing rice	ns
Gender (male)	New crops grown	0.405*
Marital Status	Reasons for growing rice	ns
Family size	Reasons for growing rice	ns
Education	Maj. cash crops grown	ns
Farm size	Reasons for growing rice	ns
Rice farming experience	Reasons for growing rice	0.730**
Other farming experiences	New crops grown	0.437*
Group membership	Reasons for growing rice	ns
Cosmopoliteness	Access to agric. Information	ns
Extension visits	New crops grown	-0.505*
Access to credit	Constraint to grow rice	0.436*
Finschaffen		
Age	Reasons for growing rice	ns
Gender	Reasons for growing rice	ns
Marital Status	Reasons for growing rice	ns
Family size	Reasons for growing rice	ns
Education	Reasons for growing rice	ns
Farm size	Reasons for growing rice	ns
Rice farming experience	Growing rice	0.941**
Other farming experiences	Maj. cash crops grown	ns
Group membership	Reasons for growing rice	ns
Group usefulness	Reasons for growing rice	0.490*
Cosmopoliteness	Access to agric. Information	ns
Extension visits	New crops grown	ns
Access to credit	Constraint to grow rice	ns

* - Correlation is significant at the 0.05 level
** - Correlation is significant at the 0.01 level
ns - Not significant

Interpretation of Relationship between Independent (Selected Factors) and Dependent (Opinion of Farmers) Variables in Rice Farming according to Locations

Chimbu

Selected personal factors were tested to determine whether or not they were significantly related to the choice of cultivating rice. The test indicates that age, gender, marital status, family size and level of education were not significant while farming experience was significant for both choice of rice cultivation and growing of other introduced crops. However, level of farmers' education was negatively significant in relation to major cash crops grown. This might be due to the fact that educated farmers are involved in other income generating activities.

Age, gender and marital status were not significantly correlated to the reasons for growing rice, suggesting that these are not critical factors that influences farmers' decision to grow rice.

Family size, measured as number of persons in a household, was also not significantly correlated to the cultivation of rice, but acts as a contingent in providing family labour available for labour intensive operations. This is in conflict with the study of Igodan et al. (1988), which showed positive correction.

It is often believed that education allow the farmer to apply innovations more effectively but studies by Rogers and Shoemaker (1971) showing relationship between education and adoption failed to confirm the existence of such relationship which is in line with the findings of this study, where education was negatively significant.

Farming experience, measured as the number of years of farming, was significantly correlated to identifying the problems in growing rice and option of growing other major cash crops. Farmers with many years of experience were able to identify and determine problems in cultivating rice and therefore able to continue with rice growing. Similar situation was also found in growing other cash crops.

Cosmopoliteness had negative correlation with source of extension. Cosmopoliteness increases an individual's exposure to more new ideas and information, and helps to increase knowledge and aspirations (Kashem et al. 1992). Farmers who were member of farmers association or groups found to experience some usefulness or benefited in one way or the other.

Extension visits and farmers' access to credit facilities had no significant correlation with the reasons for growing rice. Farmers grew rice for self-consumption, to save money from buying imported rice from stores and to sell. A few farmers grew rice just for trial or for other reasons.

Markham

The membership of farmers' association has a significant negative impact on reasons of growing rice. However, there was some evidence of significant relationship in family size and reasons for growing rice. Fifty eight (58%) of the respondents had a family size of 5-10, which indicates that family size acts as a contingent of number of family labour available for the use of labour intensive inputs in the event of cultivating rice. There was a substantial relationship between the age of farmers and the reasons for growing rice, as 30 % of rice farmers are between the age of 20 to 40 years, while 70% farmers who are above 40 years do not grow rice. This indicates that few younger farmers are innovative and tend to grow rice than the older farmers.

Gender, marital status, farm size, farmers experience in growing rice, extension visits and farmers access to credit have no significant effect to the reasons for growing rice. Also, education and other farming experience have no significant correlation to major cash crop grown. It is also evident that cosmopoliteness has no significant correlation to access to agricultural information.

Although ninety six percent of the farmers were member of farmers association or group of some sort but have negative correlation to the reasons for growing of rice.

Most farmers had land that was above 7 hectares but farm size did not significantly influences the farmers' adoption behaviour in rice, as they preferred to grow other crops.

Situm

The results indicated that age, marital status, family size, farm size and group membership was not significant to reasons for growing rice while, education had no significant relationship with farmers' choice of growing major cash crops, and also cosmopoliteness had no significant correlation to access of agricultural information.

However there were some evidences of significant relationship in farmers experience in rice farming and the reasons for the farmers' choice of growing rice. Farmers with other farming experiences had a significant relationship with the choice of growing new crops. However, extension visits had negative correlations with the farmers' choice of growing a new crop. This may be due to the fact that all extension efforts are thrusted towards other cash crops rather than rice and other new crops.

It was observed that, farmers who have access to credit tend to grow rice and are able to determine the problems in growing rice.

Finschaffen

It was found that, all personal, situational and socio-economical factors were non significant, except farmers' rice farming experience and farmers' group usefulness which had some significant relationship with the farmer's choice of growing rice.

Being a member in a farmer association or group by itself does not have any direct influence over the farmers' decision to grow rice or not, although other members in the group and/or support from the group have some significant influence in the farmers choice of growing rice.

In Fischaffaffen, most farmers (74%) have no access to credit facilities and never borrowed money from any bank or other sources. Therefore access to credit facility was not significantly correlated to the reasons of growing rice.

Other Factors Associated with Growing of Rice

Of the total of 95 farmers interviewed, with different level of farming experiences, less than half had grown rice and some of the reasons for growing rice were;

- for self consumption
- to save money from buying imported rice from store, and
- to sell the surplus rice as an alternative source of income.

Main purpose of growing rice was for self-consumption and sell only when there was surplus and this finding confirms the study by Kerua (2005), indicating that cultivation of rice by farmers was for food security and additional income.

The majority of the interviewees never grew rice and expressed their discouragement for the following reasons;

- lack of experience, knowledge and skills in rice cultivation
- lack of extension activities and visits, and
- other factors such as lack of seeds, funds and milling facilities.

This was also established in Faheys' (2006), Keruas' (2005) findings as some of the main reasons why farmers did not grow rice. However, there was no sufficient relationship between the number of extension visits and the choice of farmers growing rice.

CONCLUSIONS

Although results varied slightly at different sites, the following factors emerged across all sites:

1. Most personal characteristics of the farmers were not an important aspect in the farmers' choice of growing rice except for their experience in farming, although, age and gender had some evidence of positive correlation with the reasons for farmers to grow rice or other new crops. It implies that those farmers who have been farming for many years have the ability to include not only rice but also other major cash crops into their farming systems.

2. The reasons for not growing rice by most farmers were, lack of knowledge and skills in rice cultivation, although other factors also discouraged farmers from growing rice. Most farmers have no access to information on rice due to limited extension support or for other reasons. However, the correlation tests from Situm location indicated that extension visits had a negative correlation effect on the farmers' choice of growing new crops. This might be due to the reason that extension efforts are directed to other agricultural activities but not to rice cultivation.

3. Being a member of a farmer's association or group has benefited the farmers in some ways. One of the main benefits that stood out was that the association enabled the members to share information and establish better communication, but had no direct benefit in growing rice.

4. Cosmopoliteness had negative correlation with extension contact in Chimbu but not significant in other three locations. Although, cosmopolitiness increases an individual exposure to more new ideas and information, and helps to increase

knowledge and aspirations, this study did not substantiate these. This must be due to the fact that those who are cosmopolite concentrate more on other activities than on agriculture.

5. Lack of knowledge and information in rice cultivation and lack of access to credit sources, have been identified as constrains in rice cultivation. Therefore adequate rice training is required for farmers to produce basic knowledge, skills and techniques in growing rice and micro-credit facilities should be made available to these farmers.

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INCIDENCE AND SEVERITY OF RICE DISEASES IN SIX PROVINCES OF PAPUA NEW

Shamsul Akanda[1] and Macquin Maino,

ABSTRACT

A survey was conducted in April 2005 in nine rice growing districts covering six provinces of Papua New Guinea to determine the prevalence and status of different diseases. Eleven diseases with varying severity levels were observed with highest number of diseases in the Morobe Province followed by Eastern Highlands and East Sepik. Brown spot and sheath rot, the two seed borne diseases were consistently present in all the rice growing areas with moderate to high level of severity. Tai Chung Sen 10 (TCS 10) was the predominant rice variety grown by the farmers.

Key words: Rice, survey, disease severity, brown spot, sheath rot

INTRODUCTION

In recent years, there has been an increasing interest throughout Papua New Guinea (PNG) in growing rice as a subsistence crop. Rice crop is susceptible to a number diseases and pests, and more than 80 rice diseases have been identified throughout the rice growing countries of the world (Ou 1985).

In PNG, several diseases associated with rice have been reported (Shaw 1985; Tomlinson 1984). More recently, a number of diseases were observed on upland rice at the Agriculture farm of the PNG University of Technology, Lae and the Clean Water area in the Markham district of Morobe Province (Akanda 2004) including sheath blotch which was not reported earlier (Akanda *et al.* 2003).

A number of major rice diseases are seed borne, and with the increase in rice cultivation, it is inevitable that these diseases are likely to spread across the country affecting rice yield and quality. To-date no systematic study has been conducted to establish the prevalence and severity of rice diseases in the major rice growing provinces of PNG. Therefore, a survey was undertaken to record the incidence and severity of various rice diseases in six rice growing provinces with the view to develop appropriate strategies for rice disease management in PNG.

MATERIALS AND METHODS

General

The survey was conducted in early April 2005 in six provinces, namely Central, Morobe, East New Britain (ENB) and East Sepik in the lowlands and Eastern Highland and Simbu in the highlands. The districts and the locations visited are presented in Table 1.

Table 1: Provinces, districts and locations of the survey

Province	District	Location
Central	National Capital	Pacific Adventist University
East New Britain	Kokopo	OISCA Institute
East Sepik	Angoram, Maprik Wewak	Gavian Villages 1 and 2 Bainik area, Kimbuga Village Nungunje Village, Brandi Secondary School
Eastern Highlands	Goroka	Sipiga and Fimito Villages, Bihute Corrective Institutes, Kabiufa Secondary School
Morobe	Markham Lae	Markham High School, Munum Farm NARI and ROC - Bubia
Simbu	Kerowagi	Kondiu Secondary School, Koronigle Area

Department of Agriculture, PNG University of Technology, PMB, Lae.

On-farm observations

The following observations were made during the surveys: (i) the rice farming systems i.e. upland rain-fed or irrigated paddy field, (ii) types of varieties cultivated (iii) the growth stage of rice plants, (iii) types of diseases present on rice, (iv) the incidence of these diseases, and (v) a general judgment on the soil type of rice gardens.

Assessment of disease type and incidence

Most rice diseases have characteristic symptoms (Ou 1985; Agarwal *et al.* 1989; Webster & Gunnell 1992) and the types of diseases present on rice were identified using these references. Plant samples for diseases with doubtful symptoms were collected and brought to the pathology laboratory of the PNG University of Technology for further investigation. In the laboratory, the samples were surface-sterilized with 0.5% sodium hypochlorite and sequentially purified on artificial growth media, including potato dextrose agar (PDA) and water agar (WA). Some of these samples were placed in humid chambers of petri dishes containing moist filter papers. Growth structures of pathogens from these treatments were then observed under a microscope to confirm the disease. The disease incidence and severity was recorded as low, moderate or severe using the Standard Evaluation Systems (SES) of International Rice research Institute (IRRI 2002) and judgment based on the extent of the crop area affected.

RESULTS

General on-farm observations

The sizes of rice farms visited averaged around 0.3 ha with an exception of rice fields at Pacific Adventist University (PAU), which were over 1 ha. Both upland rain-fed and irrigated paddy farming systems are practiced with the former being the most common. Most fields visited were with rice at reproductive stage (panicle initiation, heading, early or late ripening, maturing) with a few at vegetative stage (seedling or active tillering). The rice variety Tai Chung Sen -10 (TCS 10) was observed as dominant in the coastal provinces, while Gold Mountain, a variety brought in from China in 2000 was commonly grown in the two highlands provinces visited. Other varieties were also recorded in some farms and these include: IR 42, IR 64, IR 19, IR 68, MC Apo, PR 21, PR 21 (PAU, Kabiufa or Bainik); IR 10 and IR 15 (Koronigle); Finsch white (Kimbuga), and NR1, NR9, NR15, and NR16 (National Agricultural Research Institute- NARI, Bubia and Markham High School).

The Republic of China Mission (ROC) distributes large quantities of TCS 10 seeds to the farmers in visited provinces and that might be the reason for its dominance. Recently released four NARI varieties are of good yielding and adaptability characteristics, but the seeds of these varieties are not yet produced and/or made available in large quantities to the farmers, except in the close proximity of NARI in the Morobe Province.

Assessment of disease type, distribution and severity

The survey revealed the occurrence of 11 different diseases in the survey areas. The type of diseases, their distributions, and the severity are presented in Table 2 and Figure 1. In three locations; PAU, Sipiga and Kondiu Secondary School gardens, either virus or blast-like symptoms were observed. The blast-like samples were cultured on artificial media and found containing isolates of a pathogen that causes the brown spot disease. The observed symptoms may have been severe cases of brown spot disease. Virus-like symptoms were observed in Kondiu Secondary School. Known viral insect vectors, such as green leafhoppers (*Nephotettix* spp.) and white-backed plant hoppers (*Sogatella* sp.) were seen on symptomatic plants. Leaf samples with virus-like symptoms were collected and are being maintained in silica gels for further test using molecular techniques.

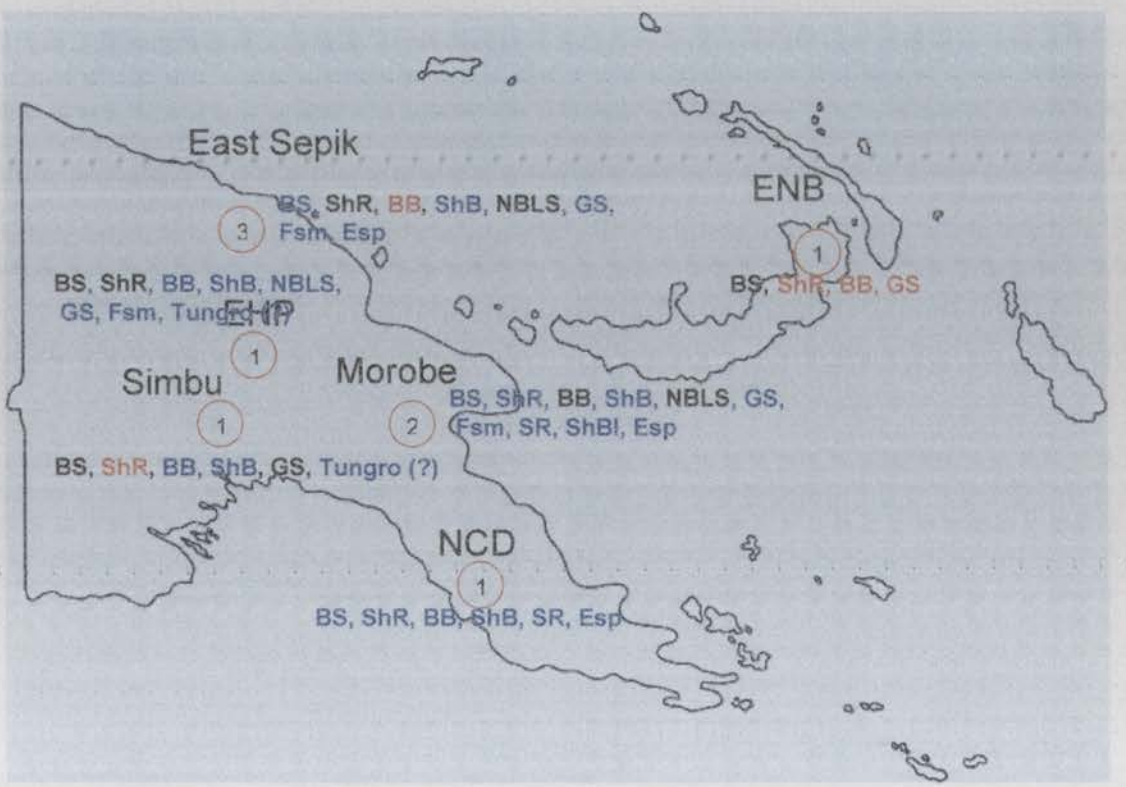
The number, incidence, and severity of the diseases also differ in different rice growing areas (Table 2, Fig 1). The maximum numbers of diseases (10) were observed in Morobe Province followed by Eastern Highlands and East Sepik provinces with eight diseases in each. Even though there was higher number of diseases in Morobe Province, most of the diseases were of low severity except for bacterial blight and narrow brown leaf spot with moderate severity. There were eight diseases in the Eastern Highlands Province; however, all of these were of low severity level. Similar severity level was also observed in case of Central Province with six diseases. In the Kerowagi district in Simbu Province, sheath rot was severe, brown spot and grain spot were moderate, whereas, bacterial blight, sheath blight, and tungro (?) were of low severity level. In East Sepik, bacterial blight was severe, and narrow brown leaf spot and grain spot were moderate;

Table 2. Severity[a] of rice diseases in six provinces of PNG

Disease	Provinces					
	Central	East New Britain	East Sepik	Eastern Highland	Morobe	Simbu
Brown Spot	L	M-S	L-M	L-S	L-M	L
Sheath rot	L	S	L-S	L-S	L	S
Sheath blight	L	-	L	L	L-M	L
Bacterial blight	L	S	S	L	L-S	L
Stem rot	L	-	-	-	L	-
Eye spot	L	-	L	-	L	-
Grain spotting	-	S	L-S	L-M	L-M	M
Narrow brown leaf spot	-	-	L-S	L	L-S	-
False smut	-	-	L	L	L	-
Sheath blotch	-	-	-	-	L	-
Viral-like symptoms	-	-	-	L	-	L

Severity: L = Low, M = Moderate and S = Severe

Fig 1: Map showing the occurrence of different diseases and their severities in six provinces of Papua New Guinea



Number within the circle is the number of districts surveyed in the Province. Disease Severity: Blue= Low, Red= Severe and Black= Moderate. Abbreviations: BS- Brown spot, ShR- Sheath rot, ShB- Sheath blight, NBLS- Narrow brown leaf spot, GS- grain spot, Fsm- False smut, ShBl- Sheath blotch, BB- Bacterial blight, SR- Stem rot, Esp- Eye spot.

and the rest five diseases were of low severity. Only four different diseases were observed in rice fields at the Organization for Industrial, Spiritual and Cultural Advancement (OISCA) Institute in East New Britain; but, all of these diseases were severe except for brown spot that was moderate. The result also revealed that brown spot and sheath rot were consistently present in all the six rice-growing areas with low to high severity. The grain spot was present in all the provinces except in the Central Province.

DISCUSSIONS

Nine rice-growing districts across six different provinces were surveyed for the presence of different diseases. A total of 11 diseases with varying degrees of severity were observed. The number of diseases recorded in Morobe Province was higher than any other provinces. The areas surveyed in the Morobe Province included both upland rain-fed and irrigated (NARI and ROC) rice fields, and this might be a probable reason for the prevalence of higher number of diseases.

At OISCA in East New Britain, four diseases were found with high severity. Continuous cultivation of rice in this particular area over a long period mostly as upland rain-fed condition might have contributed to the build up of the inocula of these diseases resulting in severe infection. Akanda (2005) reported a similar finding in the Morobe Province.

Grain spotting caused by many pathogens, including brown spot and sheath rot fungi, is on the increase across all the locations and these seed borne pathogens can spread easily when the infected seeds are planted.

Brown spot caused by *Drechslera oryzae* and sheath rot caused by *Sarocladium oryzae* were consistently present at all the sites surveyed with low to high level of severity (Table 2). Brown spot is also called a 'poor man's disease' as the severity increases with low soil fertility level, especially the deficiency of potassium and nitrogen (Havlin *et al* 1999; Miah & Shahjahan 1987; Misawa 1955). In PNG, there is relatively little information available on nutrient deficiencies on food crops (Hartemink & Bourke 2000). Agricultural land-use is with varying intensities (Saunders 1993) and generally deficiencies in nitrogen (N) and potassium (K) are common in many parts of the country (Hartemink & Bourke 2000). Vance *et al.* (1983) reported a deficiency in sulfur (S) on rice grown on alluvial soils. A recent survey revealed low N, Phosphorus (P) and K in soils of some rice growing areas in PNG (Anon. 2002). Rice in PNG is mostly grown under upland rain-fed condition without any fertilizer application. Continuous rice cultivation without fertilizer replenishment accompanied by leaching of nitrogen due to high rainfall makes soil factors highly conducive for the severe brown spot development. The brown spot is further aggravated by the water stress at any growth stage of the rice plant, particularly during the flowering to ripening stage may lead to severe grain spotting. Brown spot infection reduces the photosynthetic area that in turn affects grain filling and grain discoloration. During milling, the infected grains are broken and produce black and discolored lower quality rice. Brown spot in severe cases could be extremely devastating as was responsible for Bengal famine in 1943 amounting to a loss of 90% (Ghose *et al.* 1960; Agrios 1997). Planting infected seeds often results in seedling blight diseases and/or germination failures.

Sheath rot is also a seed borne disease caused by *Sarocladium oryzae*, which is a weak pathogen. The disease is aggravated when plants are infected and weakened by insects, like stem borer attack and infections by diseases, like tungro virus and stem rot, and water stress, particularly at the ripening stage (Miah & Shahjahan 1987; Ou 1985). Rain-fed upland rice production systems in most regions of PNG, water stress at the ripening stage is more of a common phenomenon predisposing the plants to severe sheath rot infection. Milling of infected rice produces broken and black lower quality rice similar to brown spot infection. In case of severe infection, the panicle may fail to emerge causing total crop loss (Ou 1985).

There might be several reasons for the consistent presence of brown spot and sheath rot in most of the areas surveyed including the prior presence of the fungi on alternative hosts (Akanda 2004; Miah & Shahjahan 1987; Ou 1985). However, distribution and/or use of infected seeds for planting might be one of the most probable causes (Ou 1985). Sometimes, farmers use their own seeds they collected from previous crop without realizing the presence of the diseases or the consequences that the infected seeds might have in the next crop.

There are many ways to reduce the severity of brown spot and sheath rot including hot water treatment and chemical treatment of seeds, fungicidal sprays in the field and cultural practices (Akanda 2004; Miah & Shahjahan 1987; Ou 1985). As the rice yield in the farmers field are quite low, the application of chemicals in the field may not

be an attractive proposition as well as the pesticides also have many detrimental environmental consequences. As the occurrence of brown spot is associated with infertile soil and water stress, strategies like field sanitation, balanced fertilizer application, crop rotation, adjusting planting dates to avoid water stress during the ripening stage of the crop, and good water management are effective in reducing brown spot (Havlin *et al.* 1999; Miah & Shahjahan 1987; Ou 1985). The chemical treatment of seeds may also be tried to reduce/destroy initial inoculum before the seeds are distributed and planted. Economically, it will be a better option than the field application of fungicides. Furthermore, seed producers should be very careful during the production process, including testing the seeds before distribution there by making sure that the seeds are free from any seed borne pathogens. Farmers also need to be informed and trained about the techniques of seed production and the consequences of using infected seeds for planting. If the farmers do not have access to pure disease free seeds, they can collect the seeds from their own field from areas where the plants do not have any infection and/or the level of infection is very low.

CONCLUSIONS

Based on the above survey, the following recommendations/suggestions could be made.

- Regular surveys should be conducted to various rice-growing regions to monitor the presence of diseases and the change in their status.
- At least two visits should be made to each of the region, as some of the diseases are quite specific to the growth stages.
- During the present survey, some of the major rice growing areas, namely Madang, Oro, Bereina of Central province, and Finschafen of Morobe Province could not be visited due to time constraints and funds. These areas should be visited to determine whether the occurrence of the diseases is any different from other areas.
- An awareness campaign should be initiated to educate the farmers about the dangers of seed borne diseases.
- Farmers should be trained on the techniques of production of pure and disease free seeds.
- Organizations, institutes, NGOs involved in the production of seeds need to be more careful in the seed production process. The seeds should be tested for the presence of seed borne pathogens and the infected seeds be chemically treated before distribution.
- The Department of Agriculture and Livestock (DAL) might introduce inspection and seed certification scheme as a way of ensuring the production and distribution of pure and healthy seeds to the growers.
- Production of rice seed should be concentrated only under irrigated condition as this would greatly minimize the occurrence of brown spot disease.
- ROC, NARI, Trukai Industries, NGOs and progressive farmers involved in seed production be encouraged to produce seeds of all recognized HYVs and distributed to the growers. This would give the growers more choice and flexibility of growing different varieties rather than concentrating on a particular variety and in such case the consequence could be disastrous as cultivation of a single variety for long period make it prone to resistance break down.

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a.s.l. - above sea level
yr - year
wk - week
h - hour
min - minute
s - second
k - kina
n.a. - not applicable or not available
n.r. - not recorded
var - variance
s.d. - standard deviation
s.e.m. - standard error of difference
d.f. - degrees of freedom

Levels of significance

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