INTRODUCTION AND DISTRIBUTION OF *BACTROCERA MUSAE* (TRYON) (DIPTERA: TEPHRITIDAE) IN EAST NEW BRITAIN, PAPUA NEW GUINEA.

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ABSTRACT

Bactrocera musae *(Tryon), the banana fruit fly, is a pest of bananas and plantains on the Papua New Guinea mainland. In East New Britain Province (E.N.B.) trapping and host fruit surveying prior to mid 1999 indicated the absence of this fly, despite literature records to the contrary. In mid 1999, the possibility of an incursion of banana fruit fly into the Gazelle Peninsula of E.N.B. was reported. Three trapping surveys were carried out from late 1999 to mid-2000 on the north-east tip of the Gazelle and confirmed the presence of well established banana fruit fly populations. In December 2000, a delimiting survey was carried out to map the then distribution of the fly. The fly was shown to be widespread over the Gazelle, with population foci around Rabaul and Kokopo. Market surveys of banana fruit and field assessments were also done to support the trapping surveys. Although banana finger infestation by banana fly was found to be well below 10 percent, these results confirm that* B. musae *populations are established and causing damage. Banana fly appears to be absent in West New Britain and Bougainville, but very low level populations have been detected in Manus and New Ireland. We speculate that the incursion of* B. musae *into E.N.B. may be an indirect result of relief food supplies shipped to the Gazelle following the 1994 Rabaul volcanic eruptions.*

Key words: *banana, incursion, quarantine, banana fruit fly, Dacinae*

INTRODUCTION

Fruit flies (Diptera: Tephritidae) are major pests of fruit and vegetables in most tropical and subtropical regions of the world (White and Elson-Harris 1994) and are the number one agricultural pest in Papua New Guinea (PNG) (Waterhouse 1997). Female fruit flies lay eggs into fruit and vegetables with the subsequent larvae, or maggots, feeding on the flesh of the fruit. This causes breakdown of the fruit and may promote premature fruit drop.

Drew (1989) recorded 180 species of fruit flies in PNG, of which 12 are considered pests (Dori *et al.* 1993, Leblanc *et al.* 2001). One of the most important of these pest species is the banana fruit fly, *Bactrocera musae* (Tryon). Adult banana fruit flies oviposit into hands of green bananas, where subsequent larval feeding is highly destructive to the banana flesh (Drew *et al.* 1982). Infestation of PNG bananas by banana fly averages approximately 20 percent (Leblanc *et al.* 2001). Given the role of bananas as a primary staple food and economic crop for many agricultural communities in PNG, this loss to fruit flies is highly significant. Tenakanai (1997) reported that all banana varieties are susceptible, but field observations suggest that there is varietal resistance among bananas to fruit fly attack (authors' pers. obs.). In Provinces such as Morobe, Madang and others, where banana fruit fly is common, the wrapping of developing bunches in banana leaves is a traditional technique that improves the quality of the bananas, in large part through the exclusion of fruit fly.

Drew (1989) and Tenakanai (1997) reported *B. musae* as being widespread throughout PNG *and its islands* [our emphasis]. However, Tenakanai was simply repeating Drew's claim, while it is not clear how many *B. musae* specimens from the islands, or their precise localities, were seen by Drew. From 334 individual bananas of 14 varieties collected at Kerevat (04°19'S, 150°01'E), East New Britain Province (ENB), prior to late 1999, Leblanc and Mararuai failed to rear any banana fruit flies (unpublished data). Similarly, an extensive fruit fly trapping network in ENB running from mid 1997 through to mid 1999, failed to produce any *B. musae* (with a few exceptions: see Results). These findings, plus the lack of any traditional control techniques against banana fruit fly on the islands, cast doubt on the stated claims that *B. musae* is widespread in the PNG islands, or at least in ENB.

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In September 1999, possible cases of banana fruit fly infestation in bananas in the Raluana district of the Gazelle Peninsula were detected when two boiled 'Kiakiau' banana fingers were found to have brown spots severely infested with fruit fly maggots. Bananas are the primary staple of the Gazelle Peninsular and the estimated value of bananas to the economy of the Gazelle is in excess of K15 million (S. Ivahupa, NARI internal documentation). Because of the value of bananas to the people of the Gazelle, it was important to investigate the reports of an incursion and, if true, quantify the abundance of banana fruit fly in the area. We did this through a series of intensive, short-term trapping programmes and through fruit fly rearing from banana samples. This paper documents the results of these surveys.

MATERIALS & METHODS

Trapping surveys

Three sets of trapping surveys were carried out to identify the distribution and population levels of banana fruit fly. These surveys included: (i) an initial set of surveys in the Rabaul and Kokopo areas to identify and confirm incursion; (ii) a second, intensive delimiting survey; and (iii) an extensive survey to map the fly distribution across the island provinces. All trapping was done with modified Steiner traps (Drew *et al.* 1982) that contained the male fruit fly attractant methyl-eugenol (ME), mixed with the insecticide malathion. Banana fruit fly responds strongly and positively to ME (Drew 1989) and can be reliably sampled using this technique. Trapped flies were sorted to species level by the authors at NARI's Lowlands Agricultural Experiment Station, Kerevat, and then sent for confirmation of identity to Prof. R.A.I. Drew, Griffith University, Brisbane. Additional material was screened in the genetics laboratory of Prof J. Hughes, Griffith University, and confirmed to be genetically similar to known material of *B. musae* from North Queensland.

Confirmation of incursion surveys

Three surveys were carried out from late 1999 to mid 2000 covering the coast and hinterland of the Gazelle Peninsular from the Cocoa and Coconut Research Institute station at Tavilo (04°17'S, 152°01'E) on the north coast to Takubar (04°20'S, 152°19'E) and the Gelagela resettlement area about 8 km southwest of Kokopo. Survey one ran from November 24 to December 9, 1999, and covered the Kokopo town road from Malapau road junction to Takubar. Traps were established at 23 locations covering both residential and commercial areas of Kokopo. Survey two ran from May 26 to June 6, 2000, and covered the North Coast road from Tavilo to Namanula hill outside Rabaul. Traps were set at 11 locations covering village residential areas and vegetable gardens. Survey three ran from June 19 to July 4, 2000, and covered the Malmaluan, Nangananga and Burma roads. Traps were established at 13 locations covering village residential areas with many areas under vegetable cultivation.

Delimiting survey

An intensive survey of the Gazelle Peninsula was run during December 1-8, 2000. The aim of the survey was to determine, as far as possible, the distribution of banana fruit fly at that time. Sixty-one traps were distributed, covering the major road networks of the Gazelle Peninsular at approximately 10km intervals. The trap network extended along the north coast to Lasul (04°13'S, 151°43'E), along the east coast to Sum Sum Bay (04°42'S, 151°21'E) and inland as far as Riet (04°34'S, 152°05'E) at the base of the Baining Mountains.

Extensive surveys across the island provinces

This set of surveys covered both an extensive trapping array placed before the recognition of the ENB incursion and two smaller, targeted surveys placed after the incursion to confirm or deny the presence of banana fly in key regional localities. The extensive, regional survey covered the following areas and times: West New Britain Province (WNB)(September, 19-98 - April 1999, Hoskins, Kimbe town, Silanga area, maximum of 6 traps); ENB (July-19-98 - November 1999, predominantly around the Gazelle Peninsular and Bainings Mountains, maximum of 22 traps); Manus Province (September 1998 - May 1999, Lorengau town and district, maximum of 4 traps); New Ireland Province (NIP)(August 1998 - September 1999, Kavieng town, Lugagon village between Kavieng and Namatanai and Lihir Island, maximum of 5 traps). The targeted surveys covered the Namatanai (03°39'S, 152°26'E) district of NIP (November 28 to December 1, 2000, Namatanai town, Saraha, Pire, Burabalbango and Napanta villages, 5 traps) and the Silanga (05°33'S, 150°50'E) district of WNB (December 25, 2000 to January 6, 2001, 6 traps).

Rearing from Fruit

To measure the level of infestation being caused by the banana fly incursion, bananas were purchased from local roadside markets and collected from the Lowlands Agricultural Experiment Station banana plots and from gardens in the Rabaul and Kokopo areas. Fruit were set in individual containers and kept to assess the level of fruit fly infestation as described in Leblanc *et al.* (2001). Rearing occurred at intervals over a twelve-month period from June 2000 onwards. All reared flies were identified by Drew.

RESULTS

Trapping Surveys

Confirmation of incursion surveys

Banana fruit fly was confirmed as present throughout nearly all areas surveyed (Fig 1). The pest appeared to be well established throughout and between the Rabaul (04°11'S, 152°10'E) and Kokopo (04°20'S, 152°16'E) town areas. To the west and south-east of the these centers, respectively, banana fly populations decreased. The large numbers of flies in traps around the center of the infestation (Table 1) suggested that the population had been present for some time.

Delimiting survey

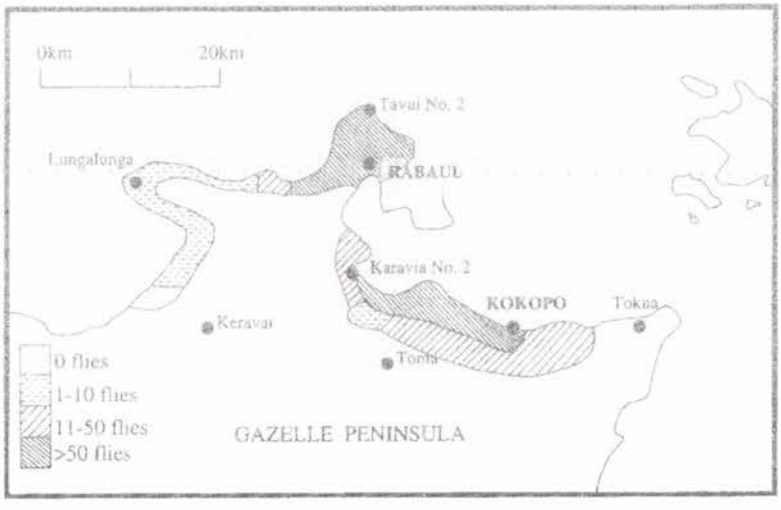
By December 2000, banana fruit fly was shown to be present over most of the north-east corner of the Gazelle Peninsula (Fig 2) and the Duke of York Islands. Population densities were highest around Rabaul, Kokopo and the heavily populated areas near these towns (including the villages and districts of Tavui, Nonga, Kuraip, Raluan, Rakunai, Nangananga, Toma, Ramale, Tokua, Rainau, Korai, Gelagela, Viviren, Reit, Dadul, Vunabaur and Ganai). However, fly populations declined with distance away from the north-east corner and became rare or absent in areas such as Kabaira, Kerevat, Warangoi, Maranagi, Lemingi, Wusing, Simbum and Warabu. The spatial distribution of fly populations suggests that the initial incursion occurred somewhere in the Rabaul or Kokopo districts and from there flies have been subsequently breeding and spreading.

Extensive Survey

Bactrocera musae was rarely collected in the extensive surveys (Fig 3). On Manus, 15 banana fruit flies were collected in comparison to 35,000 *Bactrocera umbrosa* (F.), a well established local pest species. There were no *B. musae* collected from West New Britain in either the extensive survey or the Silanga snapshot survey. In New Ireland, no banana fruit fly specimens were collected in the extensive survey, but two *B. musae* were detected in the Namatanai snapshot survey. This suggests the fly may be present in NIP but not yet established. No banana flies were collected from fruit fly traps set up on Bougainville

During the ENB extensive sampling program (October 1997 - November 1999), 83 *B. musae* were collected, all after October 1998. These flies were not recognized as *B. musae* until after the outbreak had occurred and *post hoc* re-examination occurred. In the survey database they were initially identified (by R.A.I. Drew) as a new sibling species near *B. musae*, rather than true *B. musae*. - *Bactrocera musae* is part of a species complex and is regarded as taxonomically difficult (Drew 1989). These flies thus represent the earliest positive identification of *B. musae* in ENB. The majority of these flies were collected from sites just behind Kokopo (e.g. 40 flies from 15 clearances of a trap hanging at the Vunamami Farmer Training Centre (04°21'S, 152°13'E)), but isolated individuals were trapped at more distant localities, such as Keravat and these

Figure 1. **Distribution and population density of *Bactrocera musae* on the north-east tip of the Gazelle Peninsula, East New Britain Province, as determined by local strapping from November 1999 to June 2000.***

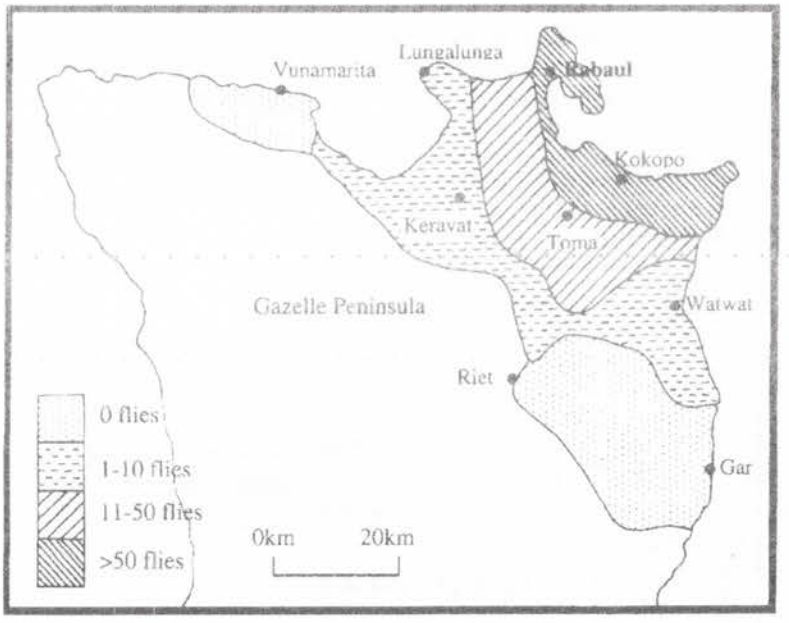


Footnote.
* Absence of flies outside the areas marked represent a lack of trapping data rather than the absence of flies, unless otherwise marked Population density contours are estimated by extrapolation between sampling points.

Table 1. **Daily catch of Bactrocera musae in selected traps during fruit fly incursion surveys of the Gazelle Peninsular, East New Britain.**

Trap location	Trapping period	No. of *B. musae*/day
Balanataman Village	1-15 Dec, 1999	67.9
Malapau Road Junction	1-15 Dec, 1999	72.5
Dalmaine Construction	1-15 Dec, 1999	72.7
Butuwin	1-15 Dec, 1999	47.3
Kokopo High School	3-15 Dec, 1999	65.8
Talina Cocoa Fermentory	1-15 Dec, 1999	34.2
Kokopo Village Resort	1-15 Dec, 1999	29.8
Ralum Police Station	1-15 Dec, 1999	61.2
Rural Dev. Bank, Kokopo	3-15 Dec, 1999	13.4
Coka Cola Depot, Kokopo	3-15 Dec, 1999	17.0
Timbur	1-15 Dec, 1999	11.8
Kinabot	3-15 Dec, 1999	59.4
Gelagela Junction, Kokopo	1-17 Dec, 1999	19.8
Gelagela	6-21 Dec, 1999	0.7

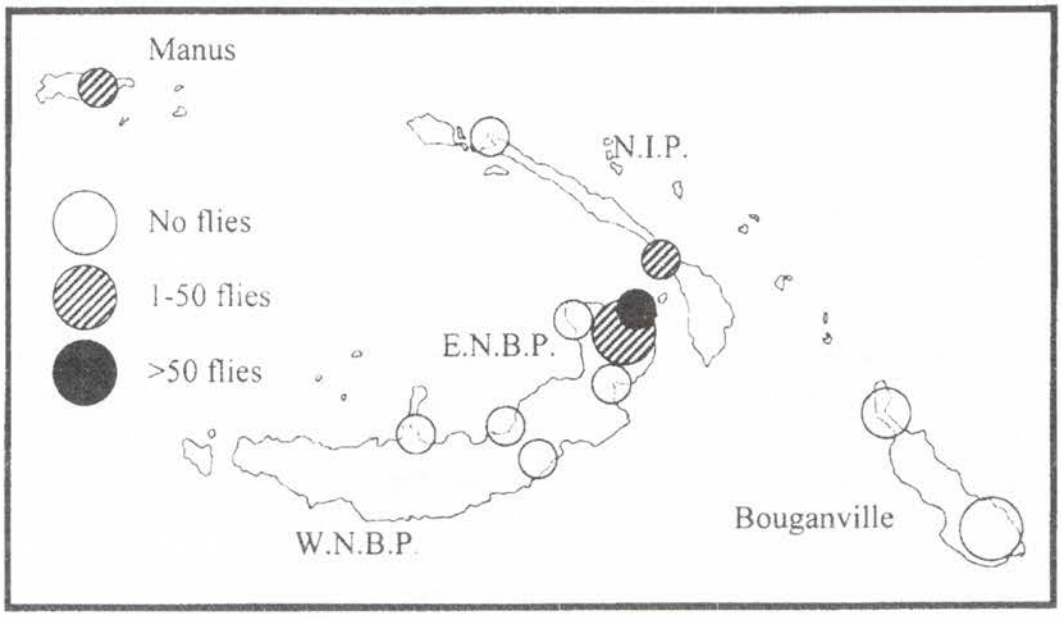
Figure 2. **Distribution and population density of *Bactrocera musae* on the north-east tip of the Gazelle Peninsula, East New Britain Province, as deter mined by local trapping during December 2000.***



Footnote:

* Absence of flies outside the areas marked represent a lack of trapping data rather than the absence of flies, unless otherwise marked. Population density contours are estimated by extrapolation between sampling points

Figure 3. **Distribution of *Bactrocera musae* in the island provinces of Papua New Guinea.**



probably represent dispersing flies.

Rearing from Fruit

Infestation rates of banana fruit collected from both markets and gardens were much lower than the average rate of around 20 percent reported for mainland PNG (Leblanc *et al.* 2001). From fruit collected from 28 roadside markets along the north and south coasts of the Gazelle, six percent infestation was recorded, caused equally by *B. musae* and *Bactrocera frauenfeldi* (Schiner). Fruit collected from 18 field locations in May and June 2001 yielded even fewer flies, with less than one percent infestation rate (Table 2). However, comments from village farmers during this collection are pertinent, for example: "*Bananas have to be harvested earlier than usual to prevent them getting damaged*". When infested fruit was collected, infestation of individual fingers was found to be heavy. One sample of seven ripe fingers, weighing 1.76 kg and collected from Tavui No 3 village (behind Rabaul town) on 12 April 2000, yielded 418 *B. musae* pupae. *Bactrocera frauenfeldi* is an abundant and wide-spread polyphagous pest species, but attacks on bananas are uncommon and are unlikely to increase above the base levels recorded. We anticipate banana fly infestation rates will climb as the *B. musae* fly population increases.

DISCUSSION

This report confirms the presence of *B. musae* on the Gazelle Peninsula of ENB and its distribution at the end of 2000: it is likely to have spread further since. In contrast to earlier literature (Drew 1989), we consider it unlikely that the species is endemic in the island provinces. This is based on the absence or rarity of the fly in trapping and fruit-rearing surveys throughout the islands prior to the ENB incursion and the absence of traditional control techniques. This contrasts markedly with the endemic banana fly populations of the PNG mainland, where trap-catch numbers are overwhelming and cultural control techniques exist.

All evidence suggests that the *B. musae* population on ENB is a relatively new incursion. If the population had been established for some time (i.e. greater than a decade) then it might be expected to occur throughout the Gazelle as its host plant, bananas, are grown all over the Peninsula. However, the population appears to be still spreading as there is a significant declining gradient in population density away from the major population foci around Rabaul and Kokopo. In addition to natural fly dispersal, it must be considered that the continual transportation of bananas is slowly spreading populations and, aiding their establishment. A lack of control measures for *B. musae* damage further increases

Table 2. **Tephritid fruit flies reared from bananas purchased from markets (March-June, 2000) or collected from gardens (May-June, 2001) in the Gazelle Peninsula, East New Britain Province.**

	Market Surveys	Garden Surveys
Number of banana varieties sampled	15	11
Number of markets/gardens visited	28	18
Fruit fly species collected *Bactrocera frauenfeldi Bactrocera musae*	*Bactrocera frauenfeldi*	*Bactrocera musae*
% infestation by both fruit fly species	6%	0.8%
% infestation by *Bactrocera musae*	3%	0.2%
Most common varieties sampled Tukuru, Katkatur, Chinese Tall.	Yawa	Kiakiau, Yawa,
Total weight of banana sampled	19.6 kg	36.8 kg
Number of banana fingers set-up	Not recorded ?	393
Average development stage of bananas sampled	mature green	mature green

the spread of the pest fruit fly.

If the incursion of *B. musae* is recent, then when or how did it arrive? Volcanic eruptions were experienced in ENB in September 1994. Extreme and widespread devastation prompted relief supplies from other parts of PNG, with fruit and vegetables being transported to the province in huge amounts. *Bactrocera musae* is present on the PNG mainland, especially in Morobe Province, where much of these food supplies were initially collected. It is thus possible that the fly was accidentally imported as an indirect consequence of the volcanic eruptions. This interpretation implies that flies were present on the Gazelle for two to four years before detection and this seems likely given the size of banana fly populations when first detected (Table 1), plus unprompted comments from local landholders suggesting maggots had been in their bananas since 1996 (authors' unpublished field records). The failure to detect the incursion until the resident fly population was large is very disturbing from a quarantine perspective, but reflects the difficulties of detecting low-density populations of fruit flies (Zalucki and Maelzer 1999). An alternative explanation for the incursion is that the fly may have been introduced in infested fruits carried by an air or sea-passengers, as there are no domestic quarantine restrictions in place to control fruit movement. Bananas are carried by 10% of passengers on PNG domestic airline flights –Putulan *et al.* in review and pose a high quarantine risk.

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