A NEW SOUTHERN DETECTION OF *ZEUGODACUS CUCUMIS* (FRENCH 1907) IN NORTHERN NEW SOUTH WALES.

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Summary

Zeugodacus (*Austrodacus*) *cucumis* is commonly found in Queensland Australia with occasional detections in New South Wales (NSW). Latitude 29°S is regarded as the southern boundary of the range of *Z. cucumis.* Previous detections in NSW were regarded as incursions that did not establish. Here, we report on regular detections of *Z. cucumis* adults south of 29°S in NSW over several months that imply an established population.

Keywords fruit fly host, cucumber fly, trapping

INTRODUCTION

Many fruit flies within the genera *Bactrocera* and *Zeugodacus* (Diptera: Tephritidae) are economically important pests of fruit and vegetable commodities that cause disruption to domestic and international trade (Clarke *et al.* 2011; Dominiak and Mapson 2017). The increased movement of fruit and vegetables globally poses a significant threat to food security (Bebber *et al.* 2014; Hertel 2015). There are 11 "high priority" tephritids present in Australia, and *Zeugodacus cucumis* (French) formerly known as *Bactrocera cucumis*, is one of seven causing significant economic losses (Sultana *et al.* 2020). In eastern Australia, Queensland fruit fly, *Bactrocera tryoni* (Froggatt) (Qfly) is the most important fruit fly pest of horticulture (Dominiak and Daniels 2012). *Zeugodacus cucumis* is one of the lesser known Australian tephritids with a limited host range compared to *B. tryoni*. However, *Z. cucumis* causes trade concerns for New Zealand (Kriticos and Leriche 2010).

Hancock *et al*. (2000) recorded up to 44 known or suspected commercial and native *Z. cucumis* host plants although 17 were considered doubtful. Five cucurbits (*Cucumis sativus*, *Cucurbita moschata, Cucurbita pepo* (zucchini)*, Cucurbita pepo* (squash *Trichosanthes anguina*) and tomatoes (*Lycopersicon lycopersicum*) were recorded as major hosts, while papaya (*Carica papaya*) and passionfruit (*Passiflora edulis*) were noted as moderate hosts (Hancock *et al*. 2000). A more recent review of hosts was reported by Dominiak and Worsley (2018), but this did not report additional hosts.

Zeugodacus cucumis is restricted to Australia and is more frequently reported in Queensland with the southern limit regarded as the 29°S latitude, roughly along the border between Queensland and New South Wales (NSW) (Dominiak and Worsley 2018). There have been many detections in NSW, but these are regarded as incursions, linked to fruit movements, with no establishments (Dominiak and Worsley 2018). Bateman (1991) suggested that *Z. cucumis* showed no tendency to spread southwards as *Z. cucumis* is a tropical species and northern NSW was a temperate climate. However, the Bureau of Meteorology classifies the coastal area in north-east NSW as "warm, humid summer" (BOM 2022), equivalent to the area around Brisbane where *Z. cucumis* is common.

Zeugodacus cucumis is not attracted to cuelure baited Lynfield traps (Dominiak and Worsley 2018). Orange ammonia and protein hydrolysate baited traps, (usually McPhail traps), have attracted male and female *Z. cucumis*, mostly in small numbers (Drew and Hooper 1981; Drew 1997). Siderhurst and Jang (2010) identified a combination of cucumber volatiles attractive to *Zeugodacus cucurbitae* (Coquillett), a species which occupies very similar niches to *Z. cucumis*. Also, Jang *et al.* (2017) reported on field trapping and longevity of the lure. Royer *et al.* (2014) assessed the commercial version (Scentry Biologicals Pty Ltd) of the new attractant and found that it attracted 41% of all trap clearances, compared to 27% by orange-ammonia. Interestingly, the control traps (McPhail traps baited with 10% propylene glycol solution) caught 16% of total clearances.

Virgilio *et al.* (2015) suggested the elevation of *Zeugodacus* to genus from subgenus and this has remained a contentious issue among some taxonomists (Hancock and Drew 2015, 2016 and 2018). Recently, Starkie (2020) examined the relative merits of molecular genetics as opposed to morphological characteristics in ascribing Australian fruit flies to genera, subgenera and various groupings. *Zeugodacus cucumis* was adopted over *Bactrocera cucumis* for the cucumber fly in this work. None of the current paper's authors is a taxonomist or molecular geneticist, so we cannot comment on the veracity of the various arguments. However, the Australian Faunal Directory (2022), the Atlas of Living Australia (2022) and Fruit Fly ID Australia (2022) have all accepted *Zeugodacus cucumis* as the name for this species. Additionally, Doorenweerd *et al.* (2018) have accepted the genus in a global checklist of 932 fruit fly species in the tribe Dacini. We have followed the consensus view for this paper.

This paper describes the initial observations of Dr Harry Fay and the subsequent surveillance activities undertaken to validate the original observations. Then we provide empirical surveillance information that is not consistent with published literature, which states that *Z. cucumis* was not resident south of latitude 29°S.

MATERIALS AND METHODS

All fruit fly surveillance targeting *Z. cucumis* were undertaken at Yamba, NSW, using three surveillance protocols which included: 1) visual observation and fly collection by hand, 2) traps baited with lures and, 3) host fruit sampling.

Hand collection and lure baited trapping

7 Oct 2021: visual observation was undertaken and one female tephritid, suspected to be *Z. cucumis*, was caught inside Yamba residence at latitude 29.442°S. This residence has papaya, tomato and passionfruit hosts. Additionally, beans (*Phaseolus vulgaris*) and cucurbits were grown nearby. The fly could have flown in from outside or most likely emerged from waste-bin residue of papaya fruit grown on the property. Although the first author was familiar with *Z. cucumis*, a photograph (Figure 1.) of the fly was provided to Peter Gillespie, Collections Curator, Biosecurity Collections, NSW Department of Primary Industries, Orange, for species verification.

13 Oct 2021: two female *Z. cucumis* caught inside residence, again most likely originating from fruit in the waste bin. Subsequently, five Biotraps (Bio Trap Australia Pty Ltd, Victoria, Australia) (Figure 2) and modified cucumber lure sent from the Department of Agriculture and Fisheries Queensland to initiate surveillance. Modified cucumber lure as per Siderhurst and Jang (2010).

22 Oct 2021: five Biotraps (three at the residence and two at the community garden) with modified cucumber lure placed in fruiting papaya trees (X2) and adjacent broadleaf tree (X1). There were tomato plants and a lime tree (*Citrus x latifolia*) within a few metres.

22 Oct 2021: one tephritid, apparently *Z. cucumis*, seen sitting on outside of Biotrap dome. Fly did not enter trap.

2 Nov 2021: two Biotraps with the modified cucumber lure placed in trees at Yamba Community Gardens (latitude 29.428°S). Hosts included bananas (*Musa* x *paradisiaca*), beans, various citrus species, zucchini (*Cucurbita pepo*), papaya, passionfruit, tamarillo (*Solanum betaceum*) and fruiting vegetables including capsicum (*Capsicum annum*), eggplant (*Solanum melongena*) and tomatoes.

17 Nov 2021: all trapping was discontinued and no flies caught at Yamba residence or community gardens.

31 Dec 2021: at Yamba residence, one Biotrap with orange-ammonia solution placed in papaya trees with green fruit. The orange-ammonia was roughly 80 ml commercial orange juice (containing reconstituted and fresh juice) and 80 ml of water plus 10 ml of cloudy ammonia (20g/L NH_3). The orange-ammonia solution was mostly replaced on a weekly basis, while flies were recovered daily. There was no orange-ammonia solution in the trap from 7/1/22 until 11/1/22 and from 18/1/22 and 24/1/22 when it contained only water. Table 1 provides details of all tephritids recovered between 31/12/21 and 3/3/22.

2 Feb 2022: Additional Biotrap baited with cuelure/dichlorvos was deployed to assess *B. tryoni* populations. Cuelure is in a green wafer (Farma Tech International Corporation, North Bend, Washington, USA.) containing 2 g of cuelure. The DDVP cube (1 cm X 1 cm) was 1.47 g (186 g/ kg dichlorvos active ingredient).

17 March 2022: specimens of suspect flies were submitted for morphological identification to Orange Agricultural Institute.

Fruit sampling

Additionally, we wanted to gather data on the host suitability index of local hosts. Papaya fruit was sampled on 15 Oct 2021 (100g), 20 Oct (210 g) and 22 Oct (100g). Fruit was placed on 2cm of garden soil in disposable food containers (6 x 12 x 17 cm) with a gauze top and held at ambient temperature for 3-4 weeks. The soil was sifted for pupal cases or flies.

Figure 1. Image of *Zeugodacus cucumis* caught in Yamba residence.

Figure 2. Biotrap used in Yamba surveillance in papaya tree.

Table 1. Captures of *Zeugodacus cucumis, Bactrocera tryoni* and *B. neohumeralis* in a Biotrap containing orange-ammonia solution between 31 December 2021 and 3 March 2022.

Period starting	*Z. Cucumis*		*B. tryoni*		*B. neohumeralis*	
	♂	♀	♂	♀	♂	♀
31/12/21	0	0	0	0	0	0
07/01/22	0	0	0	0	0	0
11/01/22	1	6	0	0	0	0
18/01/22	0	1	0	0	0	0
24/01/22	0	5	0	0	0	0
01/02/22	1	7	0	1	0	0
08/02/22	2	14	0	0	0	0
15/02/22	1	13	0	1	0	0
22/02/22	0	8	2	1	0	1
01/03/22	0	5	1	0	0	0
Totals	**5**	**59**	**3**	**3**	**0**	**1**

RESULTS

Table 1 shows the results of surveillance for *Z. cucumis* (64 flies), *B. tryoni* (6 flies), and *B. neohumeralis* (Hardy) (1 fly). We trapped 63 female flies (59 were *Z. cucumis*) and eight male flies. Regarding rearing out, no *Z. cucumis* were found in sampled fruit. At the time flies were trapped in January, there were no more susceptible host fruits on the property. Nearby properties may have had tomatoes, passionfruit and perhaps cucurbits growing. Two small capsicums were set up as above on 1/2/22, and 12 *B. tryoni* adults were recovered by 18/2/22. While capsicums are considered a host of *Z. cucumis*, they are not regarded as a major or moderate host (Hancock *et al.* 2000). Specimens of trapped flies were confirmed by Orange Agricultural Institute as *Z. cucumis.*

DISCUSSION

There is no recognised level for a breeding population for *Z. cucumis* so we used the 5-fly threshold for a breeding population of *B. tryoni* (Bateman 1991; Dominiak *et al.* 2011). Based on surveillance results, we conclude that it is likely that there is a resident population of *Z. cucumis* currently in Yamba NSW. This conclusion is at variance to previous reports (summarised by Dominiak and Worsley 2018) and could reflect a range extension due to climate change. Sultana *et al.* (2020) reported that the range of *Z. cucumis* was projected to extend south along the east coast of NSW under projected climate change.

Our detection of *Z. cucumis* was slightly south of the previously stated southern boundary. There are several possible explanations. *Zeugodacus cucumis* is notoriously difficult to attract to traps. It does not respond to the three main male lures used for tephritid surveillance (Hancock *et al.* 2000; Royer *et al.* 2014). Therefore, *Z. cucumis* could have been present for some time but not detected in any standard lure traps. Additionally, the perception that NSW did not have resident populations may have resulted in no surveillance in the Yamba region. Another less comfortable possibility is this detection is the result of climate change (Sultana *et al.* 2020). Similarly, Dominiak and Mapson (2017) reported the increased challenges for *B. tryoni* control due to weather changes. Dominiak and Millynn (2022) reported the southerly increased populations of *Bactrocera bryoniae* (Tryon) in Sydney, NSW, in the last two years.

The results of Yamba trapping are challenging for surveillance. The modified cucumber lure did not catch any *Z. cucumis,* which was contrary to expectations. However, this could have been an issue of timing, low tephritid populations or the way the cucumber volatiles were dispersed and the trap used. Additionally, in far north Queensland, *Z. cucumis* populations increase dramatically in December (Royer *et al.* 2014) and this may equate to our January trapping, allowing for the temperature delay between the two locations. Drew et al. (1978) reported that populations were smaller in southern Queensland compared to northern Queensland. The detection in a trap with the water/detergent lure is partially consistent with the trappings in control traps reported by Royer *et al.* (2014). The modified cucumber lure is known to have a short distance of attraction (Royer *et al.* 2014) and fruiting hosts in the immediate area may have been more attractive than the surveillance traps. The attraction to the water only trap on one occasion occurred when there were no ripe fruit near the trap. In this case, we suspect that the flies may have been more widespread and attracted to the yellow. We suspect that there were fewer flies in the local environment when the cucumber lure was used.

Yellow is known to be attractive to many tephritids (Prokopy 1972; Meats 1983; Vargas *et al.*1991) because it probably signals the increasing sugar content in fruit; sugar is the major component of diet removed by *B. tryoni* (Dominiak and Fanson 2017). Superficially, we conclude that traps with yellow colouring would be a key component for *Z. cucumis* surveillance. More research is required to optimise the trap design and lure for surveillance of *Z. cucumis.* This species has been caught regularly in the yellow Biotrap at Yamba (Table 1), with or without an attractant, while few *B. tryoni* have been captured over the same period in wet lure trap. This is surprising, particularly for summer, when *B. tryoni* is usually very active. The cuelure trap caught 19 male *B. tryoni* and 8 male *B. neohumeralis* between 02/2/22 and 03/03/22. The 19 male Qfly trapped in cuelure baited traps is a strong contrast to the three male Qfly caught in the wet baited traps. This ratio was very similar to the ratio reported by Dominiak and Nicol (2010). The cuelure baited BioTraps are equivalent to the Australian standard cuelure baited Lynfield traps (Bain and Dominiak 2022). The detection of *B. neohumeralis* is consistent with the range and summer peak reported by Dominiak and Worsley (2016). This data demonstrates that *B. tryoni* was present but poorly attracted to the yellow orange ammonia baited traps, consistent with Dominiak and Nicol (2010).

We had hoped to generate some host suitability index data (Follett *et al.* 2021) for *Z. cucumis* but were unsuccessful. *Bactrocera tryoni* were reared from capsicum from the same property in February and capsicums can produce 24 adults/kg of fruit (Follett *et al.* 2021).

Based on our results, we suggest that *Z. cucumis*, and particularly female flies, are more attracted to the yellow and/or trap shape than *B. tryoni.* Royer *et al.* (2014) believed the yellow colour and rounded shape of the traps used in their trials was responsible for the higher numbers of *Z. cucumis* caught in the control traps than in the Cera traps which contained protein. Perhaps there are subtle colour attraction differences in the two species. According to Meats 1983, Weldon 2003, and Dalby-Ball and Meats 2000, *B. tryoni* is attracted to various colours, but primarily yellow. Additionally, the attraction of colours and shapes to *B. tryoni* was reviewed by Drew *et al.* (2003) and Clarke *et al.* (2011).

In Australia, a liquid lure was developed and was based on orange juice and ammonia (Caldwell and May 1943). This lure attracted both female and male *B. tryoni* and this was used extensively thereafter up to current times (May 1958; Caldwell and May 1943, Clarke *et al.* 2011; Dominiak and Nicol 2010). Extensive work on novel male lures over the past decade (Fay 2010, Royer 2015) has failed to determine any attractive lures to *Z. cucumis*, despite many other species responding to unique lures for the first time. It should be noted that Royer *et al*. (2014), Siderhurst and Jang (2010) and Jang *et al.* (2017) all used wet McPhail traps in their experiments. Unfortunately, we were unable to use McPhail traps, but instead we used modified wet Biotraps. Drew and Hooper (1981) showed that *Z. cucumis* were trapped in McPhail traps baited with orange-ammonia or protein hydrolysate.

Therefore, fruit-based or protein attractants in yellow traps, similar to lures in McPhail traps, seems to offer the best approach to trapping *Z. cucumis* including at the extremities of its range. Additionally, fruit sampling is required to rank the ability of hosts to support reproduction of *Z. cucumis*. The ranking by Hancock *et al.* (2000) provides a general guide but would be enhanced by a finer analysis as provided by Follett *et al.* (2021). "Very good" hosts could be given priority for pest control; pesticides for *Z. cucumis* were reviewed by Senior *et al.* (2017) and Dominiak (2018).

The use of better trap type or lures for *Z. cucumis* will help provide a better understanding of how far this tephritid has spread southward and if this dispersal is permanent or temporary. Our work was very localised and we cannot comment on the more southerly distribution of *Z. cucumis*. However, our discovery happened coincidently with the start of a project specifically designed to explore the southern boundary of lesser known tephritids. Our work may provide insights into surveillance options for this southern range of *Z. cucumis*.

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