

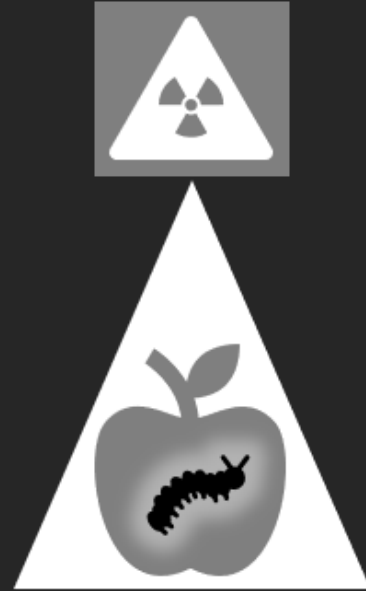


Advancing Biosecurity: A 2D X-ray Imaging Approach for Detecting Mango Stone Weevil

Maryam Yazdani Jiasheng Su
Health & Biosecurity, CSIRO

Ben James Yi Liu
Mineral Resource, CSIRO

Australia's National Science Agency



Background



Mango stone weevil is one of the quarantine pests for commercial mango crops. There are quarantine restrictions in place for the transportation of mango fruit infested with seed weevil into various markets



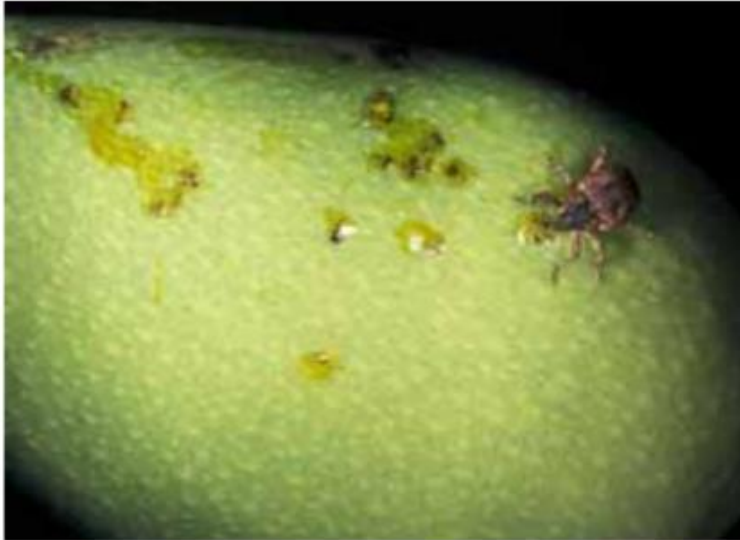
Some large mango-importing countries, including the USA, China, Japan and some Persian Gulf countries, impose quarantine restrictions on the importation of mango fruit from infested areas.



Damage caused by mango stone weevil

- Fruits being downgraded (Peng & Christian 2005; 2007)
- Reduction in yield from premature fruit drop (Verghese et al. 2005)
- Reduction in seed viability for seedling production (Follett & Gabbard 2000).

Background



Adult mango stone weevil and egg laying sites on fruit



Seed weevil pupa, larva and adult inside damaged mango seed

Background

- Egg-laying mark



Egg scar and sap



Close-up of an egg-laying mark

Challenges & Solution

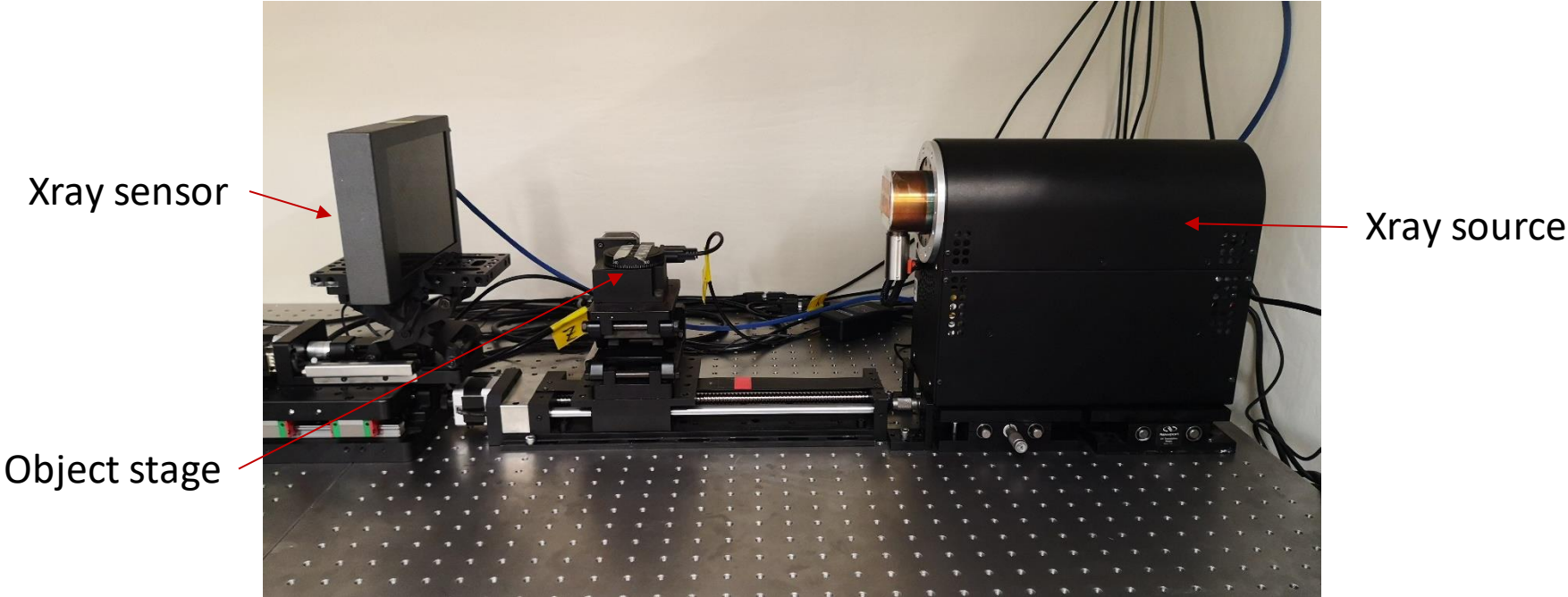
Challenges

- The small egg-laying scars are hardly visible at harvest
- hard to distinguish from physical damage
- The weevil exists only within the seed

Solution

- Non-invasive
- Fast
- Internal check

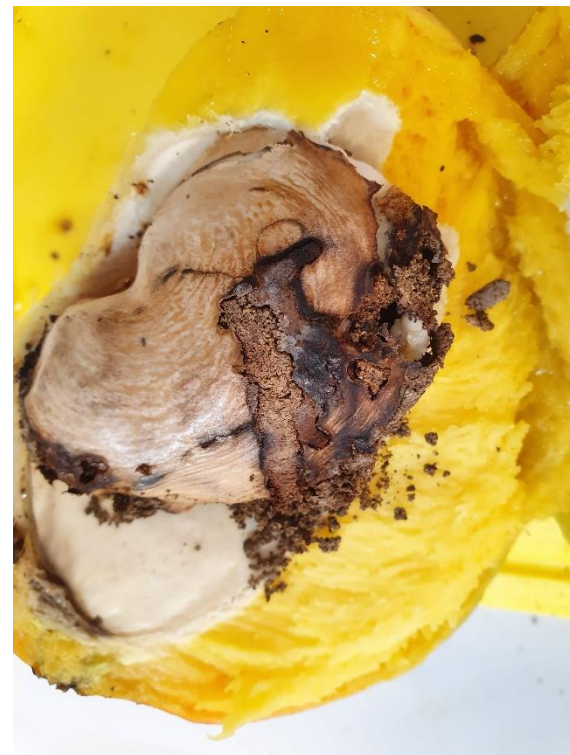
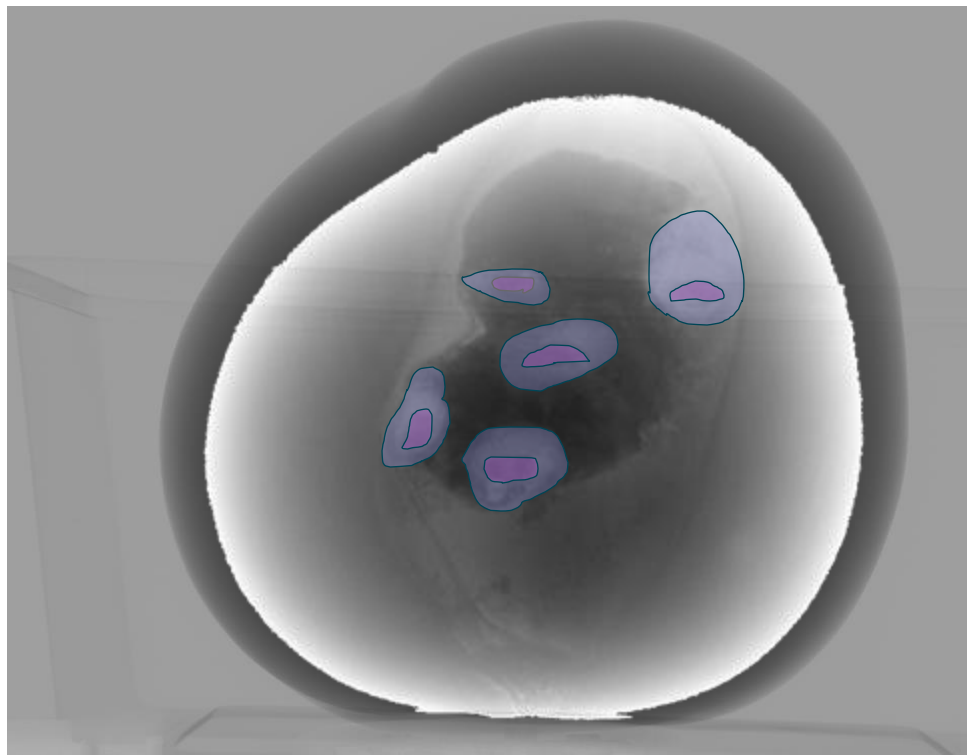
Experimental Setup



Cone beam CT

Results

Infestation
Weevils



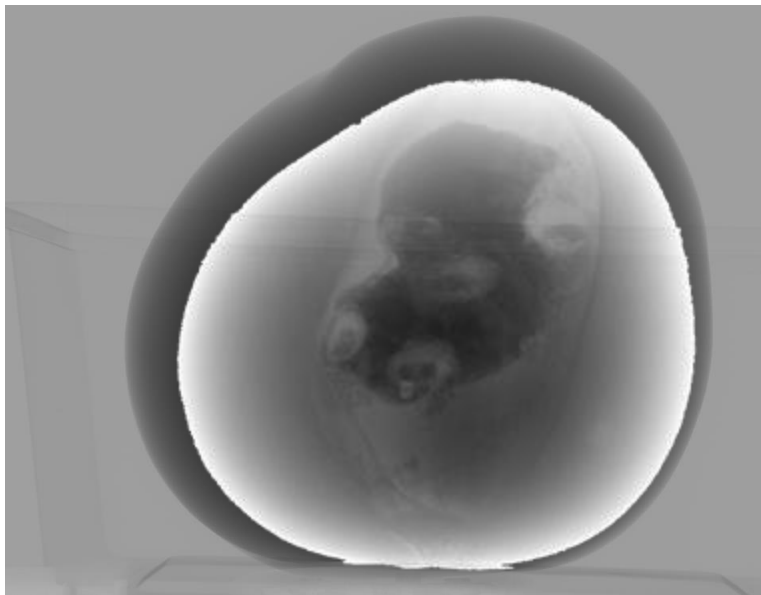
One example of mango **2D Xray** image infested by Weevils

Autonomous Sensors FSP

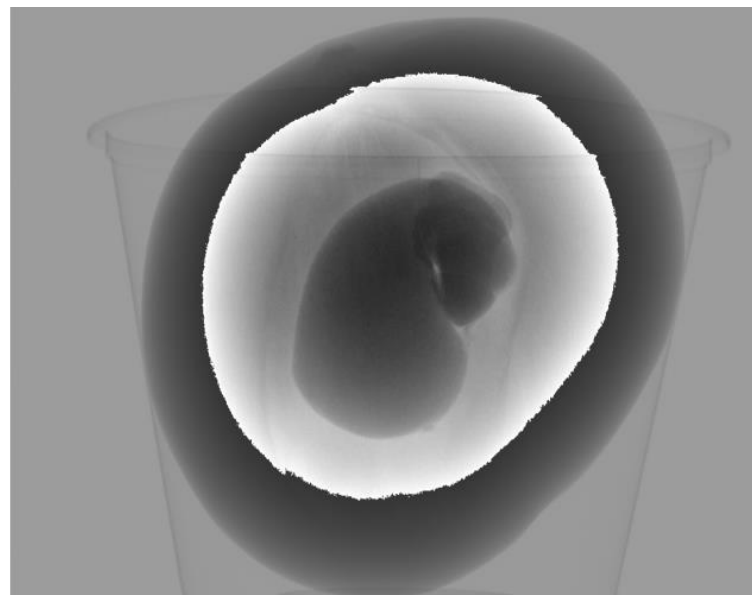
Dissection results



Results

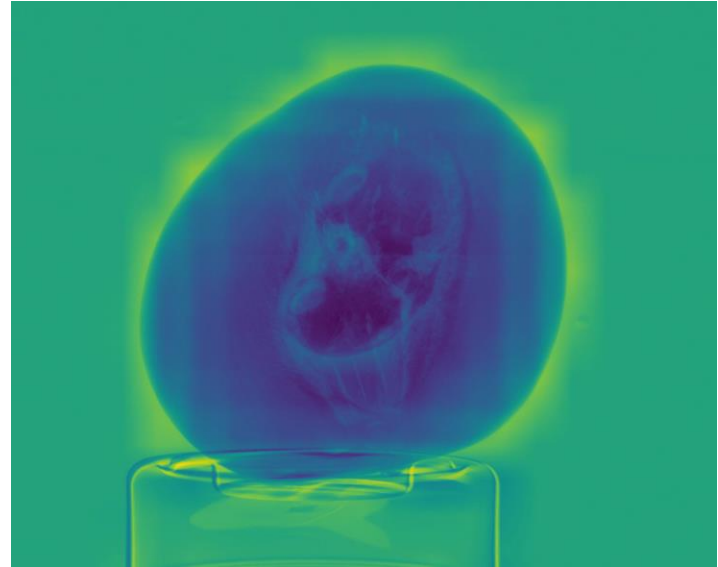
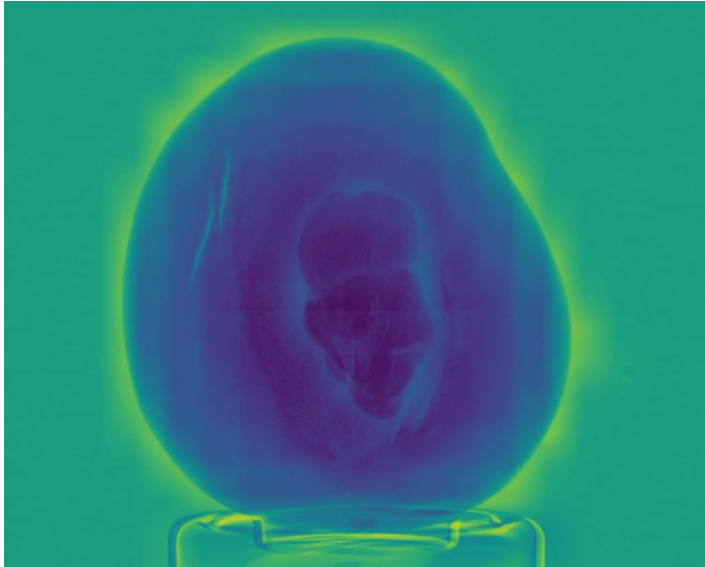


Infested



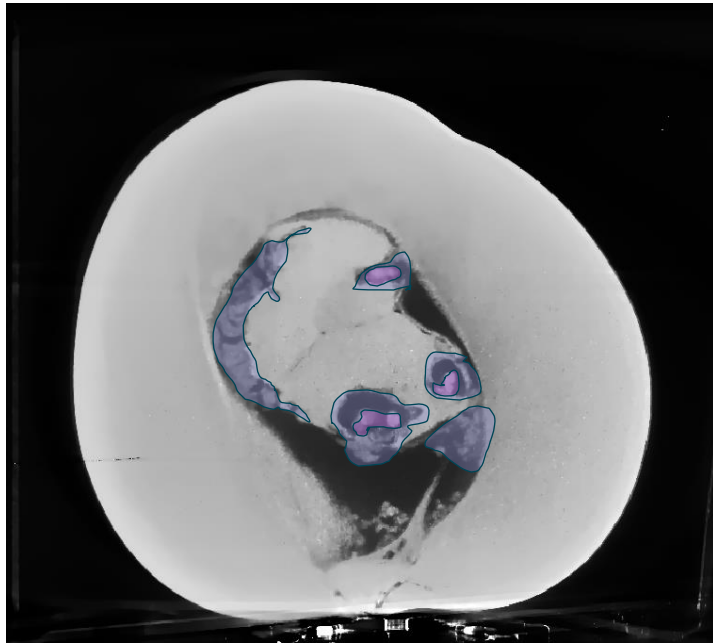
Healthy control

Results



One example of healthy (Left) and weevil infested (right) mango 2D Xray animation

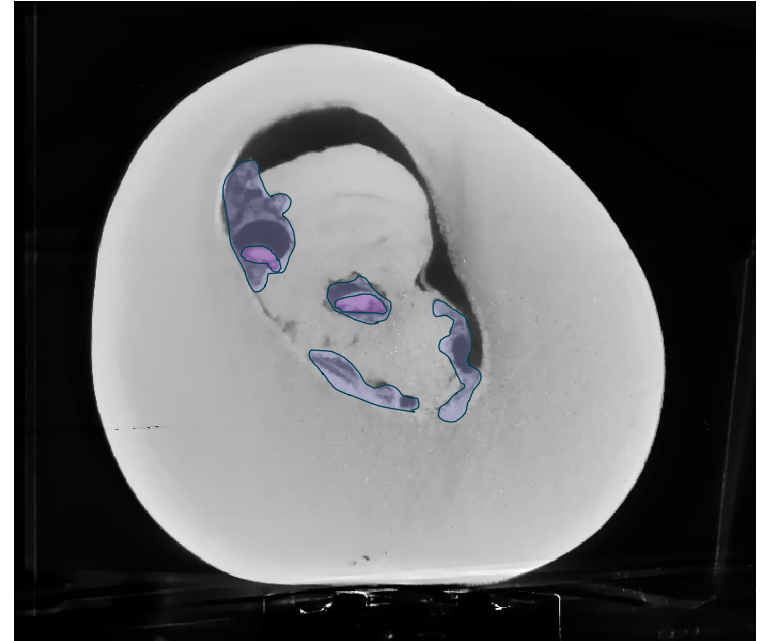
Results



Infestation

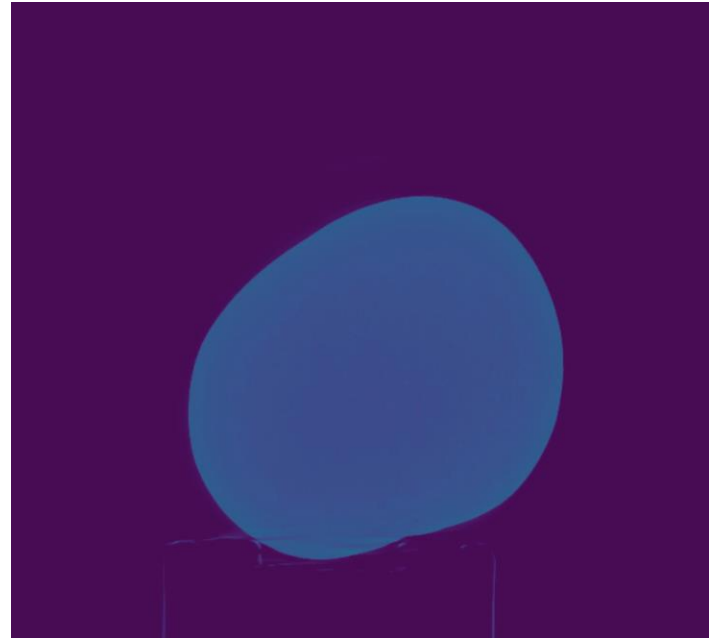
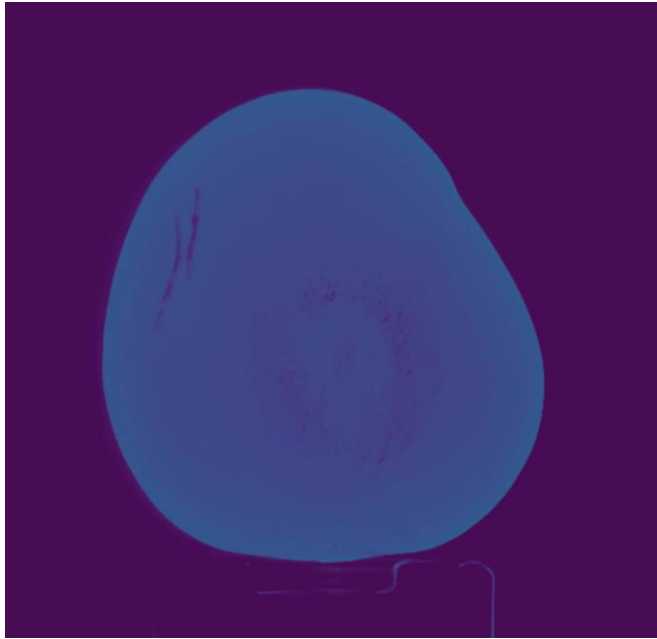


Weevil



Two slices of Mango **3D** image infested by Weevils

Results



Corresponded healthy (Left) and weevil infested (right) mango 3D Xray animation

Results

Fruit ID	Surface observation notes	Xray results 2D	Dissection notes
Mango A	Fruit had several circled areas on the same fruit.	yes(*****)	No entry tunnels, high amount of feeding damage to seed, 2x live larvae, 1x dead larva, 4x pupae
Mango B		Yes(*)	No entry tunnels, feeding damage to seed, 1x larva
Mango C		Yes(*)	Entry tunnels, feeding damage to seed, 1x pupa (only one with entry tunnels visible in pulp)
Mango D	Circled area perhaps not a weevil entry point?	No	No signs of insect damage
Mango E	n/a	n/a	No signs of insect damage
Mango F		Yes(*****)	No entry tunnels, feeding damage to seed, could only find 1x larva, 3x pupae
Mango G	Circled area perhaps not a weevil entry point?	No	No signs of insect damage
Mango H	Circled area perhaps not a weevil entry point?	No	No signs of insect damage
Mango I		Yes(*)	No entry tunnels, feeding damage to seed, 1x larva
Mango J	Good example of infested site.	Yes(*****)	No entry tunnels, damaged area to pulp near seed, feeding damage to seed, 2x larvae, 4x pupae
Mango K		Yes(**)	No entry tunnels, feeding damage to seed, 1x pupa
Mango L	Good example of infested site.	Yes (little tunnel?)	No entry tunnels, feeding damage to seed, 1x larva
Mango M	Good example of infested site.	Yes(****)	No entry tunnels, feeding damage to seed, 5x pupae
Mango N	Good example of infested site.	Yes(*)	No entry tunnels, damaged area to pulp near seed, feeding damage to seed, 1x pupa
Mango O	Control, not infested	No	No signs of insect damage
Mango P	Control, not infested, with a bit of bruising	No	No signs of insect damage

Progress & Next step

Develop mango Xray datasets

- 41 mangos (6 HC & 35 Infested/Suspicious) with Xray and 3D images

Summary the results to validate Xray image accuracy

- Observation results
- Xray and CT results
- Dissection results

Reconstruct the 3D images to see additional information

- Entry tunnels
- Larvae and Pupa
- Details structure of HC/damaged mango seeds



Continue to collect datasets



ML for Xray imaging for mango weevil detection

- Labelling
- ML models



On-belt Prototype design

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 - Thank you for invitation