

Dynamic object–fruit combinations by introduced Tanimbar corellas (*Cacatua goffiniana*) in Singapore

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APPENDIX

A1. Fruit characteristics

A1.1 *Pong-pong and Wawai fruits*

Both Pong-pong and Wawai plants (Apocynaceae family) are evergreen shrubs or small to medium-sized trees (Pong-pong: up to 15 m tall, Wawai: up to 20–25 m tall; Khanh, 2001; Lemmens, 2006) occurring in East Africa, tropical Asia and Australia, as well as Melanesia. Their fruits are drupaceous (not capsular), with fleshy exocarp, lignified (rigid and woody) endocarp, and compressed 1–2 flattened orbicular–ovoid (egg-shaped flat disc) seeds (Ly, 1998; Khanh, 2001; Lemmens, 2006; Tomlinson, 2016; Menezes et al., 2018). Fruits turn from green to red as they mature (Ly, 1998; Menezes et al., 2018). Seeds contain a significant amount of cardiotoxic glycosides (Hiên et al., 1991), such as cerberin, neriifolin, and cerberoside (Carlier et al., 2014; Menezes et al., 2018).

Both fruits share basic physical characteristics, such as the presence of a fibrous endocarp and the seed being embedded in the fruit core. It is unclear whether the endocarp of Pong-pong fruit includes a dorsal fissure similar to the one encountered in Wawai endocarps or whether mature Pong-pong endocarps split open during the germination process (seed sprouting). Notably, Pong-pong and Wawai fruits differ in shape, size, and certain aspects of fruit anatomy. In shape, the Pong-pong fruit is almost spherical to broadly ellipsoid (Khanh, 2001), approximately orange-size (8–11 cm × 7.5–11 cm × 6.5–10 cm), with a thick fibrous core (Hiên et al., 1991; Khanh, 2001). The Wawai fruit is ovoid-spherical, approximately peach-size (5–12 cm × 3–7 cm × 3–5.5 cm; Khanh, 2001; Tomlinson, 2016). In the Pong-pong fruit, the endocarp wall seems thicker than in the Wawai, whereas the seeds are of comparable size (Pong-pong, approximately 2 × 1.5 cm in diameter; Menezes et al., 2018; Wawai, approximately 2.5 × 1 cm in diameter; Lemmens, 2006). Interestingly, the Wawai endocarp is

described as transitional to fibres of the inner mesocarp, whereas in Pong-pong fruit there seems to be no clear distinction between mesocarp (fruit flesh) and endocarp (Tomlinson, 2016).

The Goffin beak could reach the inner Wawai seed matter as the beak tip is approximately 10–14 mm away from the horizontal edge of the upper mandible (Auersperg et al., 2018; Homberger, 1980). However, the dorsal fissure width limits the reach as it is much narrower (mean = 2.2 mm, min = 1.2 mm; max = 3.5 mm; O'Hara & Mioduszevska et al., 2021) than the upper mandible. Thus, the beak tip can be inserted into the fissure but without reaching the inner seed matter. Additionally, the beak is broad and highly curved (Bright et al., 2019) which might further complicate extraction where a narrow straight tool might be more effective.

A1.2 Ketapang fruit

The Ketapang is a medium-sized evergreen or briefly deciduous tree (10–40 m tall; Sosef, 1995; van Valkenburg & Waluyo, 1991), native to South-East Asia. The fruit is a medium-sized (3.5–8 cm × 2–5.5 cm) drupe, ovoid or ellipsoid in shape, green to yellow and red at maturity. The flesh of the fruit is edible but often fibrous and not delectable despite its pleasant smell. The endocarp is hard-shelled and surrounded by a 3–6 mm thick layer of juicy flesh, from which it is not easily separable. The seed is also edible, considered tasty, and contains a medicinally used oil (Sosef, 1995). Depending on the specific area and climate where the plant grows, there may be 1–2 crops of fruit per year or almost constant fruiting (van Valkenburg & Waluyo, 1991). The tree is often planted along roads and in gardens to provide shade from its long, horizontal branches and large leaves.

Table A1. Ethogram used for the frame-by-frame video analysis.

Category	Behaviour	Event type	Description
Fruit	Holding	State	interaction time with the fruit
	Biting	State	removing pieces of exocarp/mesocarp
	Beak insertion	State	inserting the tip of the beak into the endocarp (also when moving/looking around)
	Inspection	Point	closely looking into the fruit and/or endocarp
	Ingestion	Point	consuming any part of the fruit
	Locomotion	State	taking at least one step while holding the fruit in the beak/foot
Wooden fragment	Probing	State	biting branches without starting manufacture
	Interaction	State	total interaction time with a wooden fragment
	Manufacture	State	biting on a branch to produce a wooden fragment and modifications before the first insertion into the fruit
	Modification	State	modifying a wooden fragment that is detached from a branch
	Flipping	Point	360° degree turn of the wooden fragment inside the beak
	Insertion	Point	inserting a wooden fragment inside the fruit
	Combination	State	combining a wooden fragment with the fruit
	Vertical motion	State	moving/pushing a wooden fragment vertically towards/inside the fruit and beak re-adjustments between vertical motions, moving the fragment up and down along the endocarp, pulling the fragment out from the fruit
	Horizontal motion	State	levering/moving a wooden fragment along or inside the fruit, including beak re-adjustments between horizontal motions while holding the fragment and brief pauses without pushing the fragment vertically
	Subsequent	Point	inserting/having inserted two wooden fragments into the fruit
	Licking	Point	repeatedly touching the wooden fragment or the inside of the beak with the tongue
	Extraction	Point	extracting visible pieces of the seed matter with a wooden fragment
	Saving	State	placement of wooden fragment in the corner of the beak or on the fruit while foraging or manipulating endocarp and resuming the use of the same fragment
	Dropping	Point	discarding the wooden fragment
Focal	Proximity	State	close proximity to another individual
	Out of sight	State	the focal individual moves away from the video frame or turns away from the camera; all active state events are stopped

Important: ‘state events’ indicate target behaviours that started in the first frame and continued/were visible until the last frame of the video.

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