Short Note

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Water-filled Asian elephant tracks serve as breeding sites for anurans in Myanmar

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Abstract: Elephants are widely recognized as ecosystem engineers. To date, most research on ecosystem engineering by elephants has focused on *Loxodonta africana* and *Loxodonta cyclotis*, and the role of *Elephas maximus* is much less well-known. We here report observations of anuran eggs and larva in water-filled tracks ($n=20$) of *E. maximus* in Myanmar. Our observations suggest that water-filled tracks persist for >1 year and function as small lentic waterbodies that provide temporary, predator-free breeding habitat for anurans during the dry season when alternate sites are unavailable. Trackways could also function as “stepping stones” that connect anuran populations.

Keywords: conservation; ecosystem engineers; *Elephas maximus*; Htamanthi Wildlife Sanctuary.

Ecosystem engineers are species that modify the conditions or availability of resources for other species by causing and/or maintaining physical changes in the biotic and abiotic environment (Jones et al. 1994, 1997, Jones and Gutierrez 2007). Elephants (Elephantidae) are widely recognized as ecosystem engineers (Wright and Jones 2006) that can have impacts at varying spatial scales (Pringle 2008). At the landscape scale, elephants extensively modify vegetation through browsing, trampling, and seed dispersal (Buechner and Dawkins 1961, Laws 1970, Dublin et al. 1990, White 1994, Hawthorne and Parren 2000, Mosepele et al. 2009), and convert large amounts of plant

biomass into dung that is an important nutrient input for terrestrial and aquatic systems (Hoberg et al. 2002, Mosepele et al. 2009). At smaller scales, local plant species richness is enhanced when elephants open gaps in forest canopy, browsing damage to trees creates refuges for small vertebrates (lizards and small mammals), and dung piles provide food for a diversity of beetles (at least 100 species of Scarabaeoidea; Waltner-Toews 2013) and microhabitat for anurans and invertebrates (Campbell 1991, Pringle 2008, Campos-Arceiz 2009). To date, most research on ecosystem engineering by elephants has focused on savanna elephants (*Loxodonta africana* Blumenbach, 1797) and to a lesser extent, forest elephants (*Loxodonta cyclotis* Matschie, 1900) in Africa; the role of Asian elephants (*Elephas maximus* Linnaeus, 1758) as ecosystem engineers is much less well-known (Campos-Arceiz 2009). We here describe the use of water-filled Asian elephant tracks as oviposition sites by anurans in Myanmar.

Our observations were made at Nay Ya Inn (25.692° N, 95.534° E; elevation=130 m), a seasonally flooded wetland adjacent to Nam Pelin Chaung (=creek), which forms part of the northwestern boundary of Htamanthi Wildlife Sanctuary (2151 km²) in Sagaing Region (area described by Rabinowitz et al. 1995). Nay Ya Inn consists of an open expanse of wet grassland (>10 ha) on a substrate of heavy alluvial clay, surrounded by evergreen forest. The wetland is inundated to a depth of 2–3 m during the annual wet season (June through September), waters begin to recede at the onset of the dry season (October), and except for a small (<0.5 ha) spring-fed pool, the wetland is dry during March–May.

We visited Nay Ya Inn on 16 March 2016 and again on 20 March 2017 while conducting biodiversity surveys in Htamanthi Wildlife Sanctuary. Most of the wetland was dry during our visits with only a small area of open water remaining. Hundreds of elephant tracks were present around the wetland periphery, most of which appeared to be >60 days old. According to sanctuary staff manning a nearby guard station, elephants regularly visit Nay Ya Inn during November and December as seasonal floodwaters are receding. Tracks were generally elongated rather than round, probably because the foot is pushed forward in the direction of travel. Very few tracks contained water,

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Figure 1: Water-filled Asian elephant tracks containing anuran egg masses and larva in moist soil at *Nay Ya Inn* (=wetland) in Htamanthi Wildlife Sanctuary, Myanmar. Trackway with multiple tracks (A) and close-up of individual water-filled track (B).

which is unsurprising given that our visits occurred late in the dry season. Those tracks containing water appeared to have been filled by groundwater seepage. During both visits we searched water-filled elephant tracks for anuran egg masses, tadpoles, and adults. Tadpoles were captured and macroscopically examined. Following Beck et al. (2010), we measured the water depth, maximum length (direction of travel), and perpendicular width of each track containing egg masses or tadpoles. Mean values are presented here as mean $\pm$ 1 standard deviation (SD).

We found 20 water-filled elephant tracks containing anuran eggs and larva (but no adults) at *Nay Ya Inn* during 2016 and 2017 (Figure 1A and B). In 2016, anuran egg masses were present in two (60 cm long $\times$ 30 cm wide $\times$ 10 cm deep) of seven water-filled tracks within a single trackway; one track contained 12 egg masses and the other six. In 2017, tracks in three trackways contained anuran larvae. The first trackway consisted of two parallel ruts (ca. 100 cm long $\times$ 40 cm wide $\times$ 9 cm deep; probably formed when an elephant dragged its feet forward through loose muck that later dried before re-filling with water) each containing >100 tadpoles. The second trackway extended for approximately 10.5 m and consisted of 14 water-filled tracks; mean length and width were 50 ± 15 cm (range = 31–82 cm) and 40 ± 10 (range = 25–63 cm), respectively, and water-depth ranged from 4 to 30 cm (mean = 10 ± 6 cm). The variation in track dimensions suggests this trackway resulted from the passage of multiple elephants. Tadpoles were present in every track and one track also contained a single egg mass. The third trackway consisted of two water-filled tracks (50 cm long $\times$ 35 cm wide; water depth = 6 and 13 cm) spaced about 30 cm apart, each containing numerous tadpoles. Mosses and small plants growing from track walls suggested these tracks were older than others found in 2017, and coupled with their location led us to conclude these were likely the same tracks that contained

egg masses in 2016. The tadpoles examined in 2017 were of a single morphotype that we were unable to confidently identify. To the best of our knowledge, this is the first report of water-filled elephant tracks being used by anurans as oviposition sites and nursery habitat for tadpoles.

Water-filled elephant tracks are in effect small lentic waterbodies created when elephants walk across a substrate unable to support their great bulk without being modified. Trampling by large mammals has major impacts on soil structure, resulting in greater compaction and increased bulk density, which in turn can increase water retention by the track (Kozłowski 1999, Hamza and Anderson 2005). Moreover, the physical effects of trampling on soil structure are greater when soil moisture is elevated (Scholz and Hennings 1995) as was the case at *Nay Ya Inn*. Water-filled elephant tracks offer temporary breeding habitat for anurans that may be critical during the dry season when rainfall is minimal, groundwater levels drop, and alternate sites become unavailable (Gerlanc and Kaufman 2003, Beck et al. 2010). Moreover, in common with other ephemeral waterbodies, water-filled elephant tracks would seem less likely to harbor potential egg and tadpole predators, especially fish (Duellman and Trueb 1994). Hydroperiod is another critical consideration if tadpoles are to successfully complete metamorphosis before waterbodies dry and depends on the amount and frequency of precipitation, ambient temperature, and soil type and structure (Gerlanc and Kaufman 2003, Beck et al. 2010). We speculate that groundwater seepage in the moist soils at *Nay Ya Inn* maintains sufficient water in tracks and results in creation and maintenance of breeding habitat throughout the dry season. Our observations also suggest that at least some elephant tracks persist as breeding sites on the landscape for >1 year. Finally, as suggested for peccary (Tayassuidae Palmer, 1897) wallows (Beck et al. 2010), water-filled elephant tracks might also function as

“stepping stones” through an otherwise dry landscape, providing connectivity between anuran populations by increasing dispersal distance and gene flow. Our observations provide yet another clear example of ecosystem engineering by *Elephas maximus* (see also Campos-Arceiz 2009). In conclusion, we echo concerns of Campos-Arceiz (2009) that studies are still urgently needed on the role of *E. maximus* as ecosystem drivers, especially in light of the rapid decline of these large fauna.

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