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RESEARCH ARTICLE

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The behaviour and fate of translocated bull African savanna elephants (*Loxodonta africana*) into a novel environment

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Abstract

Translocation of elephants is used to mitigate human-elephant conflict in Asia and Africa. However, few studies investigate how translocations affect the movements and social behaviour of individuals following their release, which may have important implications for whether translocated animals survive and succeed. Using GPS-tracking data, we explored movements of five translocated bull elephants (*Loxodonta africana*) moved to Tsavo, Kenya, and compared them with five resident bull elephants. Position data was collected hourly for 1 year (March 2018–March 2019), and analysed to investigate home range, displacement rates, problematic behaviour and group size. Of the five translocated elephants, three were illegally killed and one continued to break fences and raid crops. Only one elephant stayed away from human settlement. We found group size and composition to be significantly different, with translocated elephants observed in smaller groups with no female elephant interactions. All elephants showed variation in home ranges and displacement rates, but differences were not significant between resident and translocated elephant groups. For future translocations, we recommend careful consideration of elephant social systems, elephant age, timing, release site and proximity to human settlements that might create human-elephant conflict. This will improve chance for success of such high-stake and expensive translocations.

KEYWORDS

African elephants, elephant movement, human-elephant conflict, Kenya, social behaviour, translocation

Résumé

Le transfert des éléphants est utilisé afin d'atténuer les conflits homme-éléphant en Asie et en Afrique. Cependant, peu d'études se sont penchées sur la façon dont les transferts affectent les mouvements et le comportement social des individus après leur libération. Ceci peut pourtant avoir des répercussions importantes sur la survie et l succès des animaux transférés. À l'aide de données de suivi GPS, nous avons exploré les mouvements de cinq éléphants mâles transférés (*Loxodonta africana*) vers Tsavo, au Kenya, et les avons comparés avec cinq éléphants mâles résidents. Les données de position ont été collectées toutes les heures pendant un an (de mars 2018 à mars 2019) et analysées afin d'étudier le domaine vital, les taux de déplacement, les comportements problématiques et la taille du groupe. Sur les cinq éléphants transférés, trois ont été tués illégalement et un a continué à briser les clôtures et à piller les cultures. Un seul éléphant est resté à l'écart des développements humains. Nous avons constaté que la taille et la composition des groupes étaient significativement différentes. Les éléphants transférés étant observés au sein de groupes plus petits sans interaction avec les éléphantes femelles. Tous les éléphants ont montré des variations en matière de domaines vitaux et de taux de déplacement, mais les différences n'étaient pas significatives entre les groupes d'éléphants résidents et transférés. Nous recommandons qu'une attention particulière soit portée aux systèmes sociaux des éléphants, à l'âge des éléphants, au moment et au site de lâcher et à la proximité des développements humains qui pourraient créer des conflits entre les humains et les éléphants pour les transferts à venir. Cela améliorera les chances de succès de ces transferts coûteux et dont l'enjeu est considérable.

1 | INTRODUCTION

Translocation is defined as the *"deliberate and mediated movement of wild animals or populations from one part of their range to another"* (IUCN, 1998). It is a management tool sometimes used as an alternative to lethal control or as a means to re-establish or boost a population that is considered too small. Translocations are also used to reduce the population of a species in small areas (IUCN/SSC, 2013) or to remove 'problem animals' from a particular area to reduce their undesirable impact directly on humans, their livelihoods and/or infrastructure (Fernando et al., 2012). Translocations are challenging and often they fail. The success of translocating animals depends on the ability of the individual to survive by finding key resources, avoiding predation and human settlement and later on reproducing in an unfamiliar environment (Berger-Tal et al., 2020).

Elephant translocation is a common strategy for human-elephant conflict mitigation, where a small number of individual elephants are responsible for many of these conflict incidents (Chiyo et al., 2012; Hoare, 2001; Mutinda et al., 2011). These 'problem' elephants engage in behaviours such as fence breaking, infrastructure damage, crop-raiding and human injury or death (Chiyo et al., 2012; Hoare, 2001). Other techniques have been tried to prevent these elephants from causing conflict, for example, de-tusking. However, this technique has been met with limited success (Mutinda et al., 2011). Despite the high cost (e.g. tranquilising, elephant transport and air support), translocation is sometimes used to deal with problem elephants in order to avoid using lethal methods of control that increasingly meet ethical objections (Fernando et al., 2012; Linnell et al., 1997; Pinter-Wollmanm, 2012).

Bull elephants are commonly identified as 'problem' elephants due to their propensity to engage in risk-taking behaviours, such as crop-raiding and moving through human dominated areas (Chiyo et al., 2012). They also go through 'musth', when they experience periods of heightened sexual and aggressive activity (Poole, 1989a). However, in some areas, female elephants are responsible for a majority of incidents (Smith & Kasiki, 2000). In a recent study by Hahn et al. (2022), they found that both sexes crop raid and deploy different behavioural tactics to do so, but only a small percent of elephants are habitual raiders. Despite this, it is frequently bull elephants that are most commonly targeted for translocation, which raises the question of the efficiency of translocation to reduce human-elephant conflict (Tiller & Williams, 2021).

As with any conservation management tool, it is important to know whether translocation works—and if so under what circumstances—before it is used as a solution. However, few studies exist that examine the success of these operations, and there is little documented insight into behavioural responses or information to establish guidelines to increase the chances of success during translocation operations. Tracking the movement of released animals can provide us with insight into how they adapt into their new environment, and how long it takes them to find key resources such as water and food (de la Torre et al., 2021; Fernando et al., 2012; Goldenberg et al., 2021; Pinter-Wollman et al., 2009).

In Sri Lanka, Fernando et al. (2012) studied tracking data from 12 male Asian elephants identified as problem animals. These elephants were captured outside protected areas and translocated to national parks. Post-release, all 12 elephants left the protected areas and became involved in incidents of human-elephant conflict. Seven broke perimeter fences and five were killed during the study period. Pinter-Wollman et al. (2009) analysed the outcome of translocating nine radio-collared females and three bull elephants to Tsavo East National Park in 2005. These 12 elephants were part of a large-scale operation in which 150 elephants were translocated out of the Shimba Hills region, in response to escalating human-elephant conflict and the impact the elephants were having on the endemic plants of the region. Although the operation was considered successful at mitigating human-elephant conflict, 11 of the elephants left Tsavo East and either returned back to the Shimba Hills or went to other sites. Of the 109 translocated elephants who were accounted for, 85 elephants survived while 24 elephants died within the first 2 months. This was due to a variety of reasons: one was killed by poaching; two were shot by the wildlife authority; six died during transit; three from unknown causes and 12 calves went missing and presumably died. The study also found that, following translocation, bulls and calves were more likely to die than females (Pinter-Wollman et al., 2009).

In East Africa, translocations are still relatively rare compared to South Africa, where the first translocation was in the 1970's, and where this type of management has been fairly common practice (Dublin & Niskanen, 2003). The first elephant translocation in Kenya was in September 1995 and June 1996, when the Kenya Wildlife Service moved 26 elephants during five different operations from Mwea National Reserve to Tsavo East National Park. During this operation, five of the elephants died (three during immobilisation and two a few days after release). Monitoring of the remaining 21 elephants was not undertaken so the success of the operation remains a mystery (Njumbi et al., 1996). Since then, there have been 18 other translocations in Kenya, predominately in response to elephant overpopulations (Appendix S1). Within these operations there are several documented cases of mortality (Muir, 2000; Pinter-Wollman et al., 2009) and 'homing behaviour', where the elephants reject their release site and try to return home to their source site or natal territory often migrating through human dominated landscapes in the process (Muir, 2000; Pinter-Wollman et al., 2009).

Given the relatively few cases of well documented translocations of African elephants in East Africa and the scarcity of studies investigating the impacts on movements and social behaviour following release (Goldenberg et al., 2019; 2021), we aimed to address this information gap. A sample of bull African savannah elephants (*Loxodonta africana*) ($n = 5$) were scheduled to be translocated by Kenya Wildlife Service from Northern Kenya to Tsavo West National Park, approximately 500 km apart by road. We used this opportunity to fit GPS tracking collars to each elephant upon release. GPS tracking data from March 2018 to March 2019 allowed for the comparison of the movements of five translocated bull elephants with five collared resident bull elephants in Tsavo East and West National Parks who were collared at the same time. We aimed to understand the individual response of translocated elephants after release; to compare the movement of the translocated elephants and resident elephants; and to determine if translocated elephants would continue to fence-break and crop raid in their new environment.

2 | MATERIALS AND METHODS

2.1 | Study animals

This study compared the movement of five translocated bull elephants and five resident bull elephants. The five translocated bull elephants (*Solio, Sangare-Tsavo, Bullet, Mshauri and Saidimu*) came from Solio, Sangare, Borana and Lewa wildlife conservancies in Laikipia, Northern Kenya. These five elephants had been identified as 'problem elephants' by the Kenya Wildlife Service, based on reported incidents of crop raiding and fence breaking behaviour. Three of these elephants (*Bullet, Mshauri and Saidimu*) had their tusks trimmed in the past to try to prevent them from breaking fences. However, they learned new tactics and continued to break through fences 6–12 months after the tusk trimming operations (Mutinda et al., 2011). The decision was made by the wildlife authority in conjugation with the conservancy managers to translocate these elephants 500 km away to Tsavo National Park in southern Kenya to reduce human-wildlife conflict and to reduce operational costs in the fence repairs caused by the elephants. See Table 2 for ages of the elephants.

The elephants were darted during the wet season, loaded into crates, tranquilised and then transported separately by road to Tsavo for 12–18 h. Upon arrival in Tsavo, they were hard released immediately into different areas of Tsavo West National Park (Figure 1). The five resident bull elephants were from different areas of Tsavo West and Tsavo East National Park and were collared only a month earlier than the translocated elephants in February 2018.

2.2 | Collars and collaring

Translocated and resident elephants were fitted with satellite collars (Savannah Tracking GL200 GPS). These collars consisted of a GPS unit, a VHF transmitter beacon and a battery integrated into one unit. The collars were fitted by a team including a veterinarian from the Kenya Wildlife Service (KWS) and Save The Elephants personnel. All national protocols on capture and animal handling were followed (KWS, 2016).

2.3 | Study site

The Tsavo Conservation Area (TCA) in south-eastern Kenya covers approximately 42,000 km^2. The ecosystem comprises of semi-arid bushland and acacia-savanna forest and is home to Kenya's single largest elephant population of nearly 15,000 individuals (Waweru et al., 2021), and possibly as many as 17,000 (Lamprey et al., 2020). The short-wet season occurs from October to December, followed by longer rains from March to May (Tyrrell & Coe., 1974). Patterns of rainfall are unpredictable in Tsavo, ranging from 250 to 700 mm, with an average of 550 mm annually (Ngene et al., 2017). There are two permanent water sources in Tsavo (the Galana River and the Tsavo River) and numerous seasonal rivers, including the Tiva and Voi rivers (Wijngaarden, 1985). There are three national parks within the TCA, which include Tsavo East, Tsavo West and Chyulu Hills. Sections of the parks are fenced (electric fences with 1 m 'outriggers'), mainly in areas that directly border human areas (see Figure 1). Outside the parks in the TCA there are human settlements, small-scale farming, private ranches, conservancies and a number of large community ranches, which act as a vital corridor and dispersal area for wildlife (Smith & Kasiki, 2000). The communities living in these ranches practice nomadic pastoralism, sedentary livestock keeping and small-scale farming. Commercial livestock keeping occurs in two

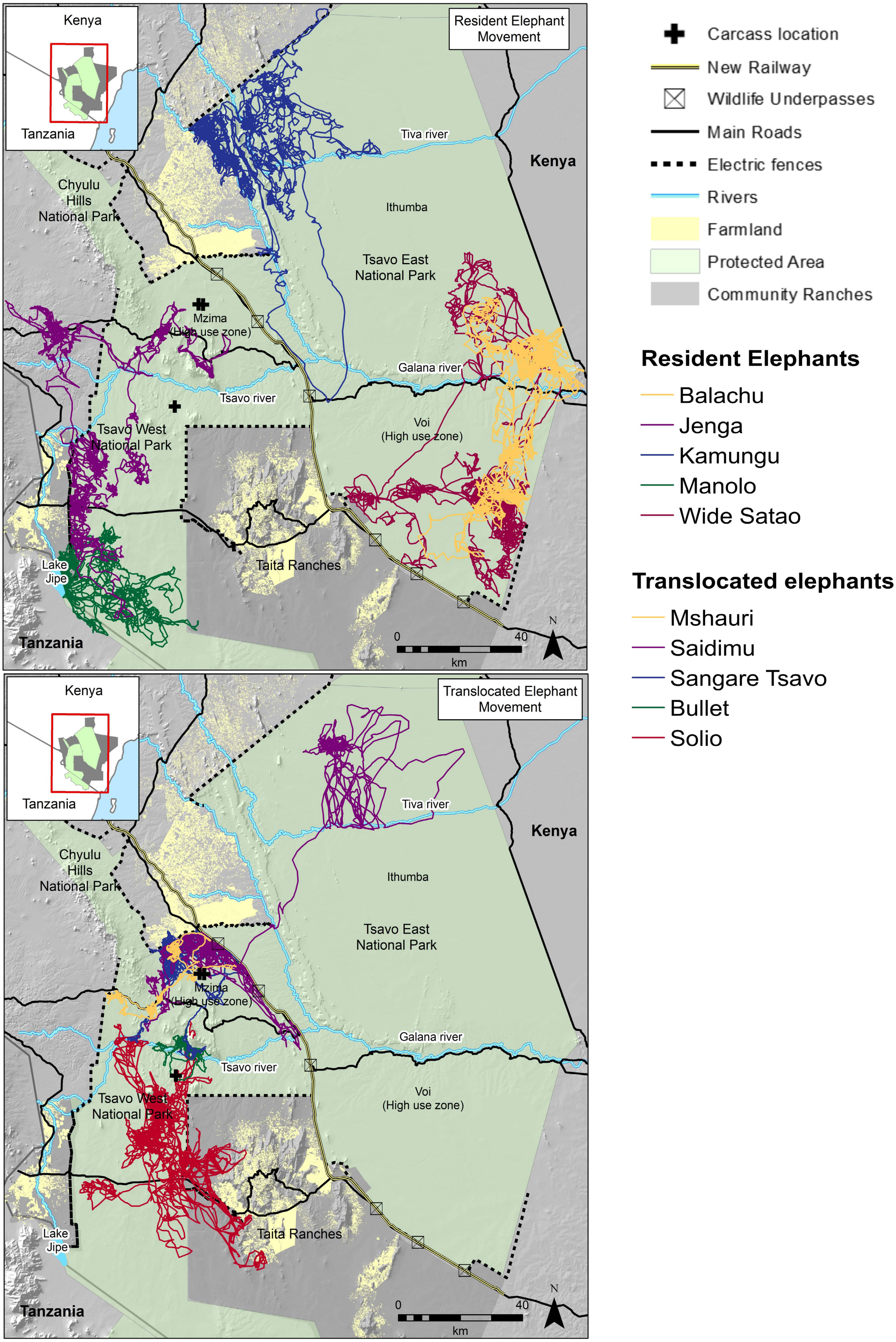

FIGURE 1 Movement tracks of the resident and translocated elephants from March 2018–March 2019 across the Tsavo Conservation Area

TABLE 1 Details of resident and translocated bull elephants including home range estimates of elephants using Minimal Convex Polygons (MCP) and time spent in the National Park and farmland

Bull elephants	Estimated Age in years	Monitoring duration	MCP (km^2)	Time Spent in PA (%)	Time in Farmland (%)	Time in Community Ranches/Grazing land (%)	Status
Resident elephants							
Balachu	42	365 days (Feb 18–Feb 19)	2833	99	0	1	Alive
Kamungu	25	365 days (Jan 18–Jan 19)	4352	89	1	10	Alive
Wide Satao	44	365 days (Feb 18–Feb 19)	4550	100	0	0	Alive
Manolo	40	365 days (Feb 18–Feb 19)	1206	39	0	61	Alive
Jenga	35	365 days (Feb 18–Feb 19)	4343	63	3	28	Alive
Translocated elephants							
Saidimu	20	365 days (Mar 18–Mar 19)	5831	100	0	0	Alive
Sangare-Tsavo	35	365 days (Feb 18–Feb 19)	999	98	2	0	Poached
Solio	45	365 days (Feb 18–Feb 19)	3038	73	2	26	Alive
Mshauri	35	113 days (Mar 18–Jul 18)	587	100	0	0	Illegally killed
Bullet	40	121 days (Mar 18–Jul 18)	219	100	0	0	poached

ranches (Galana and Kulalu) as well as large-scale farming across the west and central parts of the ecosystem.

Cutting through Tsavo East and Tsavo West National Parks is a new high-speed railway on a raised embankment, and next to this railway are a number of other types of linear infrastructure. These include the 100-year-old railway, the Mombasa-Nairobi highway, two high voltage power gridlines, two oil pipelines and the Mzima water pipeline (Okita-Ouma et al., 2021).

2.4 | Elephant movement data

All the tracking collars were set to acquire GPS fixes at 1-h intervals. The tracking data for the 10 elephants was retrieved using the "STE Downloader" program, which connects via the internet to a Geographical Information System server, where the data are transferred, stored and continuously updated (Wall, 2015). The program interface lets users conduct advanced selection and filtering operations on stored locations to extract data for analyses (Okita-Ouma et al., 2021). Elephant GPS data, collected from collars, were filtered to remove any GPS errors by using an upper, biologically-based threshold speed of 7 km/h (elephant hourly movement distances do not exceed 6.5 km) (Wall et al., 2014). Data were projected on the Universal Transverse Mercator (UTM) WGS-84 reference system.

2.5 | Individual elephant responses to translocation

All elephant movement tracks were collected at 1-h sampling frequencies and 1 year of data was used for this analysis. To determine the amount of time that the elephants spent outside the national parks in farmland, we created a farmland layer by on-screen digitising of 2018 CNES/Astrium satellite imagery at 5 m resolution in QGIS (QGIS Development Team, 2019), using the Open Layers plugin. We then applied the 'Select by Location' function in ArcMap 10.7.1 to identify the GPS fixes that were within the farmland layer (ESRI, 2019). Subsequently, we worked out what proportion of these fixes were within the elephants' entire one-year tracking history. To ensure that no elephant fixes in farmland or community land were missed, each section of elephant tracks was also manually verified against a base map of high-resolution imagery in ArcMap. To work out when the elephants crossed the new railway, the main roads (Mombasa highway and Taita-Taveta highway) or fence, we used the 'Select by Location' function in ArcMap to identify the segments of tracks that went through the railway, road and fence lines.

2.6 | Home range, cumulative frequency and moving average

Daily range size was estimated using a 100% Minimum Convex Polygon (MCP). We used 100% MCP to ensure no range was lost when calculating range accumulation Given that we were estimating daily range size (i.e. 24 GPS points at 1-h fixes), we selected MCP as a simple, well used and assumption-free means by which to estimate space use (Worton, 1995). To calculate MCP home ranges we used the adehabitatHR package (Calenge, 2006) within the R statistical software program (R Development Core Team, 2020).

2.7 | 24-hour and weekly displacement rates

To measure 24-h displacement rates of each elephant, we worked out the distance travelled between the start and the end of the day using the GPS point taken at 00:00 and 24:00. We then worked out the mean displacement rate for each elephant. For weekly displacement rates, we used the distance from the first hour location fix at the start of the week to the last fix at the end of the week plotted, against mean weekly rainfall.

2.8 | Rainfall

We compared weekly displacements patterns to mean monthly rainfall data, which was based on daily readings from weather stations across the Tsavo ecosystem. The locations were: (1) Save The Elephants Research Centre, Sagalla, Voi, representing rainfall for Tsavo East NP; (2) Tsavo Trust headquarters, Mtito Andei representing data for Tsavo West NP; and (3) The Maasai Wilderness Conservation Trust office, Kuku Ranch, representing data for Chyulu Hills NP.

2.9 | Group size, composition and musth

Monthly aerial and ground monitoring of the resident and translocated elephants was conducted from July 2018 to March 2019 by either a gyrocopter aircraft, Supercub aircraft or Land Cruiser vehicle. In total, 66 observations were recorded with each elephant being observed individually 9 times (once each month). There were two elephants who were not observed each month (Saidimu had 7 observations and Kamungu 6) due to dense vegetation making them invisible. Observation days of resident and translocated elephants did not overlap as Tsavo is a very large ecosystem. During observations of the individual elephants, group composition was recorded using the following categories: (1) Lone bull–if the elephant was alone; (2) Bull group—if the individual was with other bulls; (3) Mixed group—if the individual was with female elephants and their calves. These data were verified from photos taken during each observation. We also recorded if elephants were in musth. Aerial observations lasted approximately 5–10 min which was enough time to collect all the data and not disturb the elephants. Ground observations were longer ranging from 5 to 30 min depending on the location of the elephant. We used non-parametric paired Wilcoxon Signed Rank Test to detect any differences in the mean group size of the translocated and non-translocated elephants. Finally, we used a Fishers Exact Test to determine if there was a difference in whether translocated elephants were seen more often on their own than resident elephants.

3 | RESULTS

Out of the five elephants translocated to Tsavo, two were poached (tusks removed) and one was illegally killed (arrow wound to the leg from a conflict incident; tusks still present). Two out of the three dead elephants were killed during the one-year study period and one was killed just after the study period (Table 1).

3.1 | Individual elephant responses to translocation

Bullet and *Mshauri* did not travel far immediately after translocation, which took place during the rainy season (Figure 2d,e). During their first month, Bullet travelled a total distance of 160 km and *Mshauri* 263 km. This was less than the residents travelled in their first month after being collared. For example, *Balachu* travelled 470 km and *Kamungu* travelled 360 km.

Bullet and *Mshauri* both stayed close to a few temporary water sources (different from each other) and moved much more slowly compared to the other elephants (Figure 2a–c). *Mshauri* started to travel further after 3 weeks, and *Bullet* after about 5 weeks. This increase in movement coincided with the rains stopping and the temporary water sources drying up. In July 2018, 4 months after translocation, *Mshauri* died of bullet wounds. Two weeks before he died, he travelled to the northern border of Tsavo West National Park (TWNP), which is next to human settlement which is likely where he was shot in the leg, a wound that ultimately killed him. Bullet was poached inside the National Park for his ivory, the method of killing i.e spear or gunshot was undetermined. Neither *Bullet* or *Mshauri* left the National Park, nor did they break through any fences.

During his first week after translocation, *Sangare-Tsavo* headed north in TWNP (towards the direction of his original home in the north) and, over the next 3 weeks, he travelled to the park boundary where he walked up and down the northern fence line repeatedly, without breaking through. He then made two journeys south towards the Galana river but returned back north each time. In November 2018 (8 months after being translocated), *Sangare-Tsavo* broke through the northern electric fence and went into farmland (Figure 2b). Subsequently, he crossed the fence line another 39 times, spending 2% of the total year in farmland. Sangare-Tsavo was poached just after the study period on the 25th of May 2019 (Figure 3) inside the National Park, 14 km from the boundary.

Saidimu exhibited more exploratory movement behaviour than either *Bullet* or *Mshauri*. From May 2018 to July 2018, when there was little or no rain, he spent a majority of his time in the Mzima Springs high use area of northern TWNP, where there are a number of waterholes being fed by lodges (Figure 4). During this time, he also advanced towards the railway to the east 17 times, but turned back. In December 2018 (6 months after his first attempt), he succeeded in crossing the railway and continued north into Tsavo East National Park, past the Tiva river in the Ithumba area (defined as a low use area due to lower tourist traffic here). During 1 year of tracking, Saidimu did not enter farmland or break through fencing. 100% of his time was spent inside the national parks ending up in the far northern end of Tsavo East.

Solio also exhibited more exploratory movement behaviour compared to Bullet and Mshauri. From his release location, Solio travelled south from the Mzima high use zone to the Murka low use zone in TWNP, where he stayed for 6-months. Solio first attempted to cross an electric fence a month after being translocated, but he failed and turned away. For 8 months, Solio made a few more unsuccessful attempts to cross an electric fence, but from November 2018, he succeeded in crossing/breaking the 10–12 strand electric fence. He then crossed back and forth 124 times along two different fence lines from November 2018 to March 2019. Solio also crossed the unfenced Taita-Taveta highway 65 times from November 2018 to March 2019. In January 2019, he entered farmland by breaking

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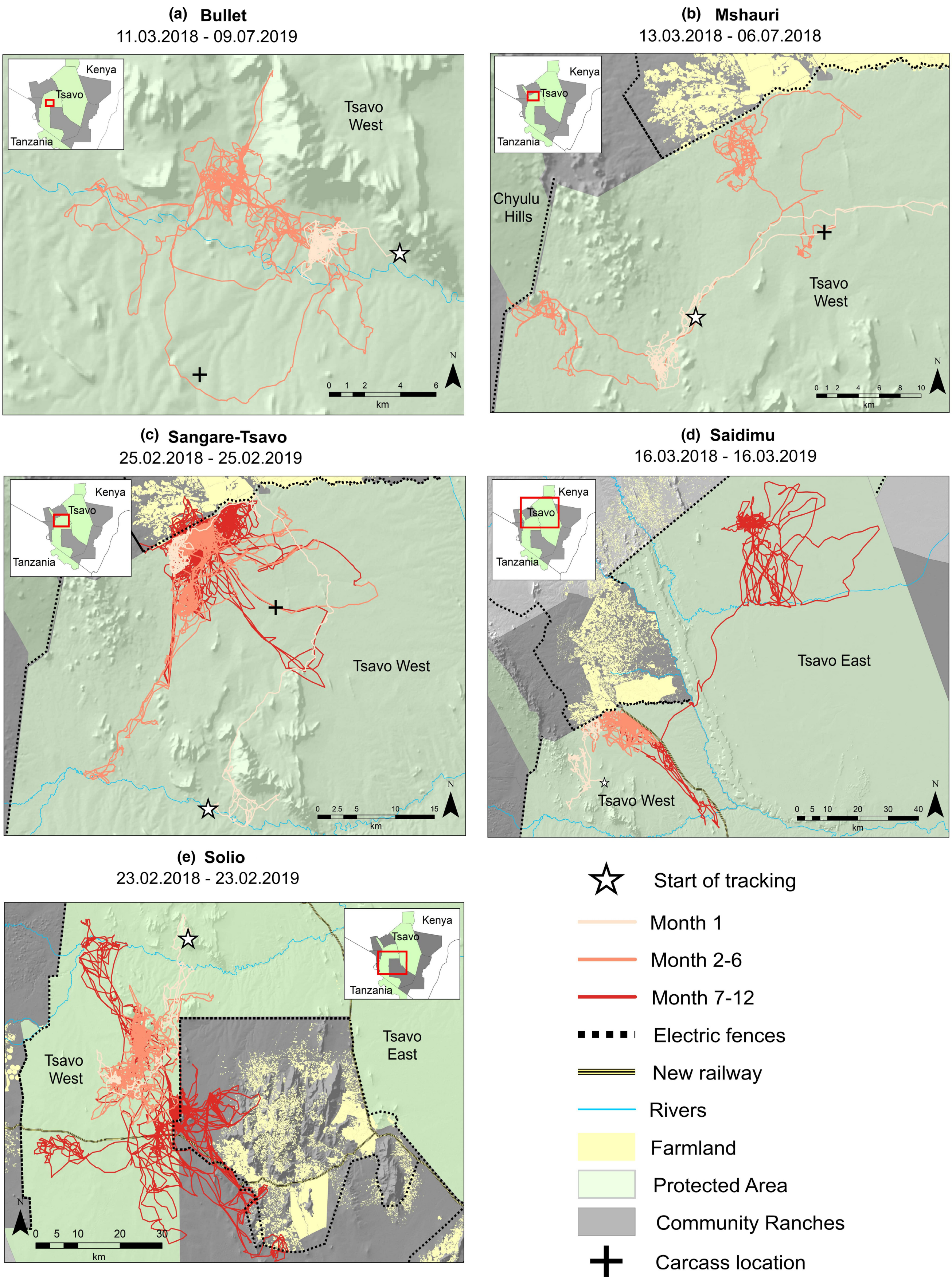

FIGURE 2 One year of movement tracks of translocated elephants (a) Bullet; (b) Mshauri; (c) Sangare-Tsavo, (d) Saidimu; (e) Solio, showing locations of the start of tracking "☆" and carcass locations "+" of the elephants that were illegally killed

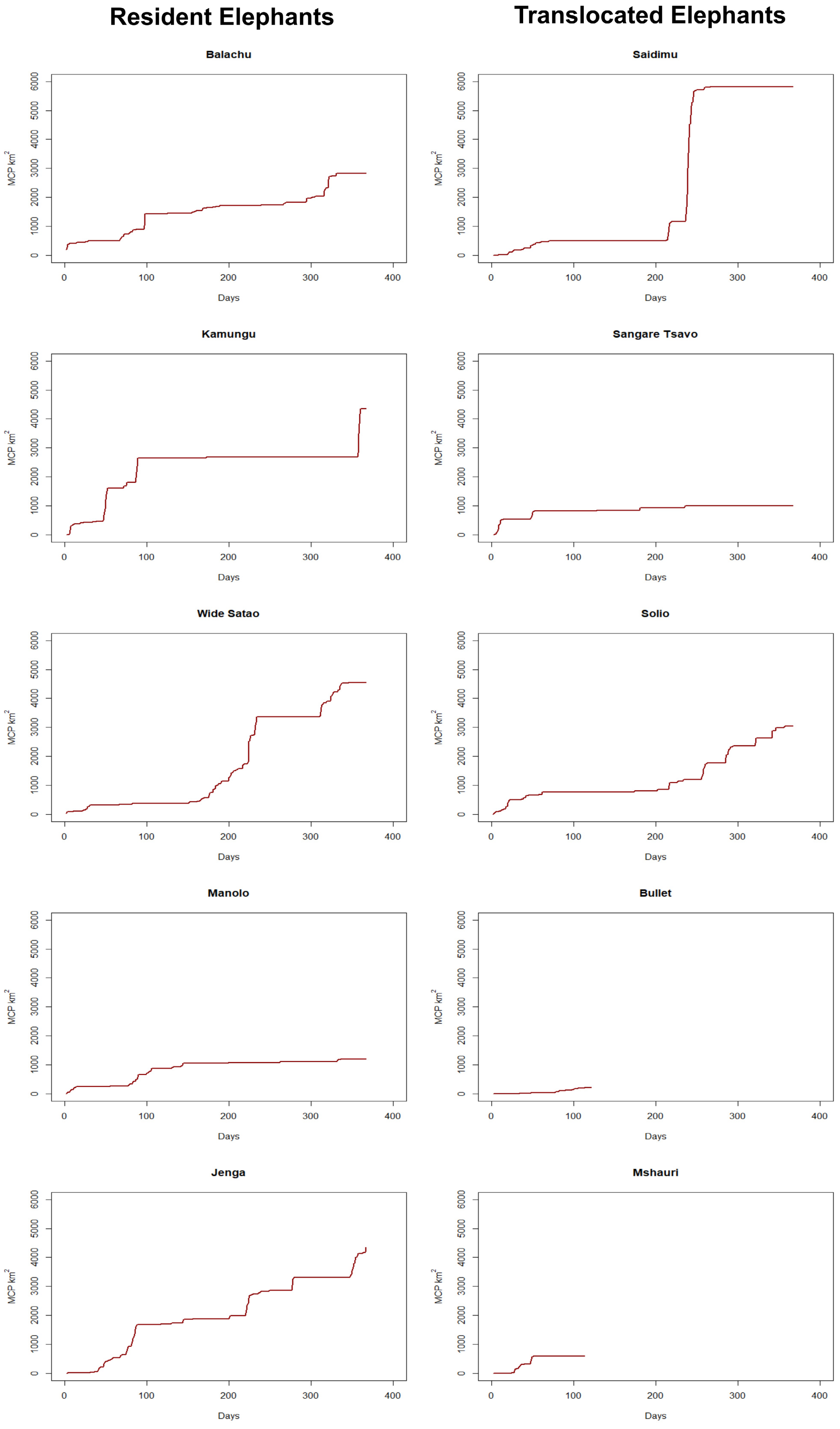

FIGURE 3 The cumulative frequency using 100% Minimum Convex Polygon MCP of the translocated and resident bull elephants over 1 year (2018–2019)

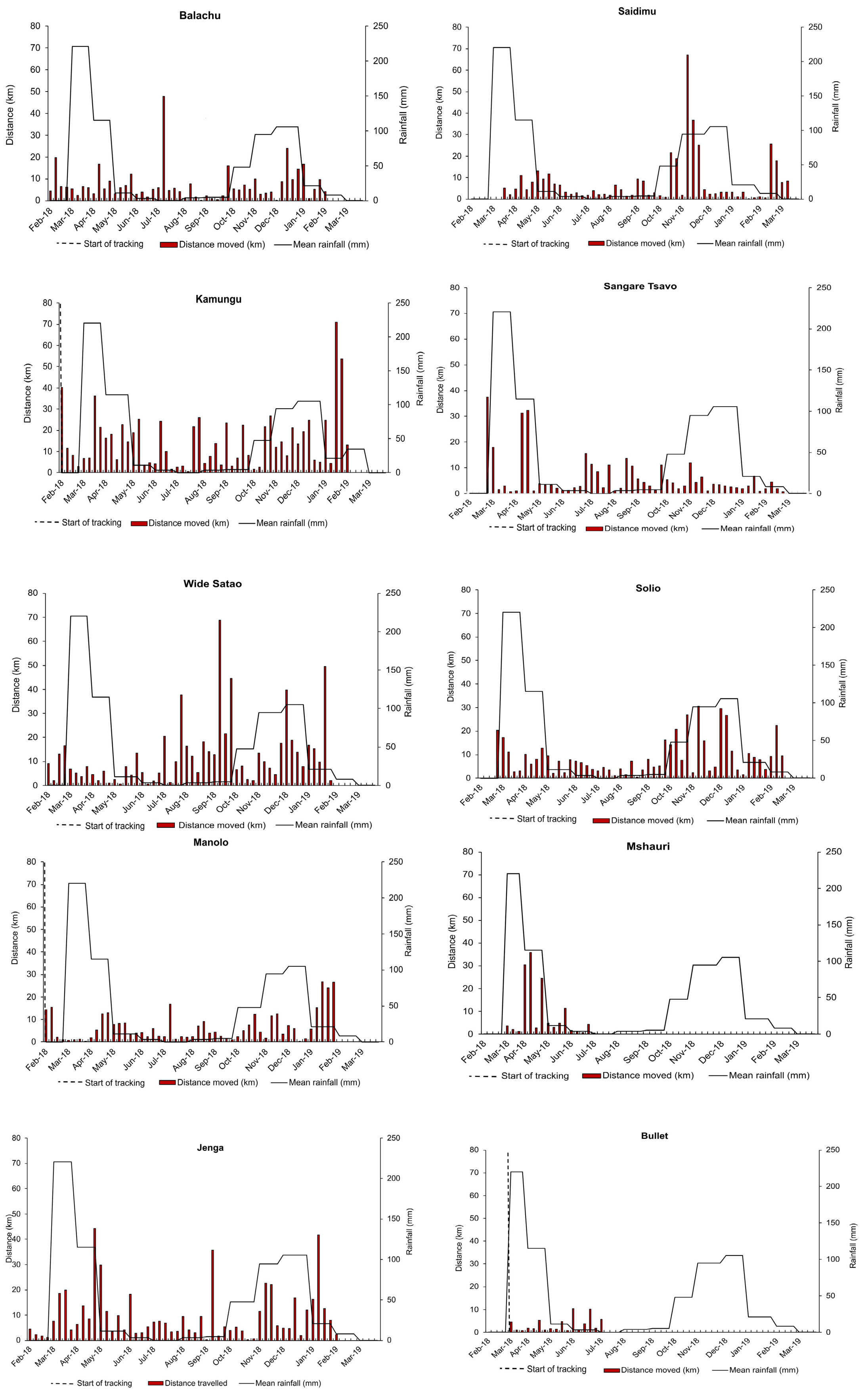

FIGURE 4 Weekly displacement rates of resident elephants and translocated elephants and mean monthly rainfall in the Tsavo Conservation Area

TABLE 2 Mean 24-h displacement rates of resident and translocated elephants (km)

Elephant	Mean 24-h displacement distance (km)
Resident elephants	
Balachu	4.36 ±0.22
Kamungu	4.68 ±0.23
Wide Satao	4.28 ±0.22
Manolo	3.44 ±0.19
Jenga	3.71 ±0.16
Translocated Elephants	
Saidimu	4.37 ±0.30
Solio	4.29 ±0.21
Sangare-Tsavo	2.88 ±0.15
Mshauri	2.33 ±0.34
Bullet	2.27 ±0.23

through at least two sections of an electric fence. Over the year, he spent 2% of his time in farmland, 26% in community land and 73% in the national park (Figure 2c).

3.2 | Home range and cumulative frequency

When comparing the translocated and resident elephants home ranges over 1 year, minus the two poached elephants (*Mshauri* and *Bullet*) there was no significant difference (W = 8, p = 0.9207). The largest translocated elephant home range was 5831 km^2 for *Saidimu* (Table 1), most likely due to two widely separated ranges. For 220 days, *Saidimu* had a home range of <100 km^2. However, there was a sudden spike in his moving average at day 220 (Figure 3) as he set off to explore a new area in Tsavo East National Park and his home range increased to 5831 km^2.

Bullet and *Mshauri* (translocated elephants) had the smallest home ranges (Table 1). However, these are the two elephants that were poached after approximately 4 months of being translocated. For the first month of *Bullet* being translocated, his home range was <100 km^2. It was only at around day-70 when his moving average spiked and he started to explore a new area (Figure 3). This increased his home range to 219.35 km^2, but he was then poached shortly after.

3.3 | 24-hour and weekly displacements

Three of the translocated elephants (*Sangare-Tsavo*, *Mshauri* and *Bullet*) had a smaller mean 24-h displacement rate compared to the resident elephants. During most 24-h periods, the translocated elephants were likely to move <1-km, but they had occasional long-distance movements. Resident elephants were likely to move <2-km and had more long-distance movements compared to the translocated elephants (Table 2).

Weekly displacement rates varied between all the elephants, but there were no clear patterns between long-distance movement and rainfall (Figure 4). The elephants shifted their ranges all the time. However, *Kamungu* (resident elephant) had a different pattern from the other elephants as he exhibited displacement rates of more than 20-km for 17 different weeks. This was a lot higher compared to the other elephants: *Wide Satao's* weekly displacement rates were < 10-km for 38 different weeks; *Manolo's* < 5-km for 30 different weeks; *Jenga's* < 10-km for 37 different weeks; *Saidimu's* < 5-km for 33 weeks, *Sangare-Tsavo* <5-km for 38-weeks and *Solio's* < 12-km for 27 different weeks.

3.4 | Group size, composition and musth

The translocated elephants had a significantly lower mean group size each month compared to the resident elephants (n = 63, W = 615, p = <0.001). From July to December 2018 (6-months), mean group size of the translocated elephants was below 3 individuals. The mean for resident elephants was consistently above 3 individuals and reached 19 individuals in August and September (± 1.208) (Figure 5).

Translocated elephants were observed on their own predominately more than resident elephants (n = 66, x = 19.48, p = <0.001). Two translocated elephants were most often seen on their own (*Saidimu* = 6 out of 7 observations; *Solio* = 7 out of 9). *Sangare-Tsavo* was observed associating with other bulls 5 out of 9 times during observations. None of the translocated elephants were observed associating in mixed groups with females and calves. Resident elephants spent time on their own but had more interactions with other bulls and mixed groups (Table 3).

Two of the translocated elephants (*Saidimu* and *Tsavo Sangare*) and three resident elephants (*Wide Satao*, *Jenga*, *Manolo*) were recorded in musth.

4 | DISCUSSION

Over the first year that five elephants were translocated into Tsavo West National Park, three elephants were illegally killed, one elephant continued to raid crops and one was deemed a successful translocation. This low survival rate has been documented in other elephant translocations such as Sri Lanka (Fernando et al., 2012) and Kenya (Pinter-Wollman et al., 2009) and other species such as cougars (Ruth et al., 1998), wolves (Bradley et al., 2005) and black bears (Linnell et al., 1997).

4.1 | Individual responses to translocation

Each of the five elephants displayed different exploratory tactics after being translocated, which has also been observed in other elephant translocations (Pinter-Wollman, 2009; Stüwe et al., 1998). The

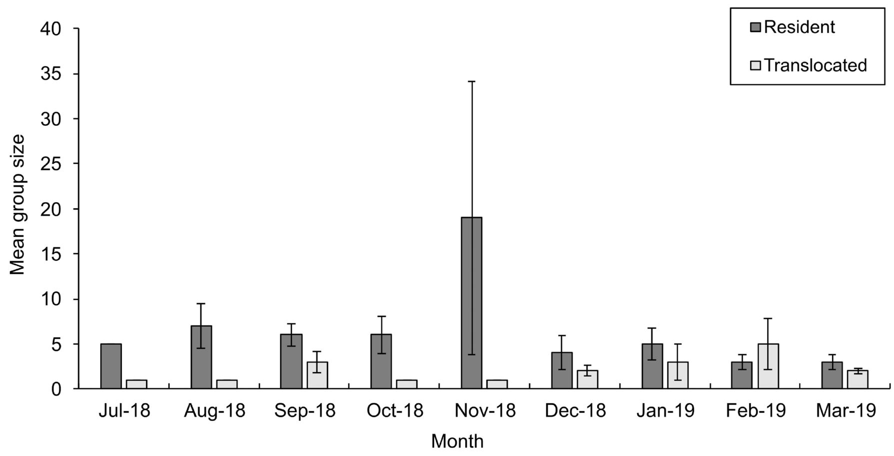

FIGURE 5 Monthly mean group size (with SE) of the translocated bull elephants and resident bull elephants

TABLE 3 Group composition observed each month of translocated and resident elephants

Elephant	Jul 18	Aug 18	Sept 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19
Translocated elephants									
Sangare- Tsavo	Lone	Lone	Bulls	Lone	Lone	Bulls	Bulls	Bulls	Bulls
Solio	Lone	Lone	Bulls	Lone	Lone	Lone	Lone	Lone	Bulls
Saidimu		Lone	Lone	Lone	Lone	Bulls	Lone	Lone	
Resident elephants									
Wide Satao	Bulls	Mixed	Bulls	Bulls	Bulls	Lone	Mixed	Mixed	Bulls
Manolo	Bulls	Bulls	Bulls	Bulls	Bulls	Bulls	Lone	Lone	Bulls
Kamungu		Bulls	Bulls		Mixed	Mixed	Mixed	Bulls	
Jenga		Mixed	Bulls	Bulls	Bulls	Bulls	Bulls	Bulls	Bulls
Balachu	Bulls	Bulls	Bulls	Bulls	Lone	Lone	Bulls	Bulls	Lone

two elephants who were poached within 4 months of release (Bullet and Mshauri), showed little exploratory behaviour compared to the other elephants. This may have been due to a number of reasons. For example, stress from the translocation experience itself, being left on their own with unfamiliar elephants and resources (Pinter-Wollman et al., 2009), or anchoring themselves in one area to try and understand their new environment before dispersing.

Bullet and Mshauri stayed close to a few temporary water sources during the first month in their new habitat, which was during the rains. However, when the rains ceased, they started to move further away, presumably forced to look for other sources of permanent water. Elephants possess sophisticated cognitive capacities which they use to track relationships and resources over their long lifespans (Fishlock et al., 2016). In semi-arid environments, such as Tsavo, elephant spatial movement is strongly structured by water resources, with the locations of water and forage sites determining individual elephant ranging patterns (Bolker et al., 2009; Chamaillé-Jammes et al., 2013; Loarie et al., 2009; Polansky et al., 2015; Wato et al., 2018). However, unlike the resident elephants which showed normal exploratory behaviour after collaring, the translocated elephants would have lacked this knowledge of where to find dry season forage and water. They may have faced a trade-off between foraging and drinking, as often during the dry season forage is depleted near water sources, forcing elephants to move further afield for water (Chamaillé-Jammes et al., 2013; O'Connor et al., 2007). Additionally, the elephants would have been unfamiliar with the habitat and food availability in Tsavo, as it differs greatly from Laikipia. Laikipia is a milder environment, with a cooler climate (average min and max temperature 10.4–20.5°C) compared to Tsavo (average min and max temperature 19.3–29.0°C) with more permanent water, grass and evergreen vegetation. Therefore, the timing and drop-off location of a translocation is an important factor to consider during the planning process (Dublin & Niskanen, 2003). Translocation during the wet season comes with the risk of the elephants being caught out, not knowing where to find permanent resources as the landscape dries up, which may have been the case for Bullet and Mshauri. Translocating elephants into habitats that are similar to their natal area could help to improve the success rate of the translocation. This increased success rate could be facilitated through reduced stress, based on prior ecosystem imprinting that may occur and an increased foraging efficiency in familiar areas (Stephens & Krebs, 1986; Stamps, 2001). However, if the translocation is close to their home geographically as well as ecologically, they are more likely to try to return there. Moreover, translocating bull elephants in pairs, or with known associates, has been documented to improve the transition for the individuals and to increase success rates, making them more likely to explore a new habitat (Dublin & Niskanen, 2003; Evans, 2006; Garai & Carr, 2001).

For Bullet and Mshauri, stress could have also made them more vulnerable to poaching if this meant that they were less alert or had to spend longer feeding in the open. Stress, detected by high concentrations of glucocorticoids in the body, has been recorded in elephants after translocations (Pinter-Wollman et al., 2009; Viljoen et al., 2015) and can lead to malnutrition, dehydration, increased susceptibility to pathogens, compromised reproductive success and altered behaviour (Adams et al., 2004; Jones et al., 1997; Letty et al., 2003; Liptrap 1993; McKinstry and Anderson, 2002). Their age may have also predisposed them to higher stress levels, as older and heavier bulls respond less well physiologically to darting and are at a higher risk of stress and developing severe complications from being immobilised (Atkinson et al., 2012; Hernandez, 2014; Hofmeyr et al., 2012; Paterson, 2014; Sanchez, 2011).

Only the translocation of the elephant Saidimu can be classified as successful in the period of study. He has settled close to the permanent water of the Tiva River, in the north of Tsavo East NP, where there is little human disturbance and has not continued with his old habits of fence breaking and crop raiding, despite the challenge of having to cross the Mombasa highway and railway to get to his new home. This is in contrast to Solio—the only other elephant who survived—who has started regularly entering community lands and crop-raiding again. Saidimu's ability to adapt to a new environment may be attributed to his relatively young age (20 years old). By the time male elephants reach their early twenties, they have dispersed from their natal herd and are in a highly transitional stage in their life, of changing sexual rank, state, behaviour and associations (Poole, 1989a, 1989b, 1996). Thus, they have greater behavioural flexibility and adaptability, and consequently have better survival rates (Evans, 2006). Moreover, there is less impact associated with the removal of a younger bull from an ecosystem compared to an older bull, as younger bulls are less established in elephant hierarchy.

Destructive behaviour such as fence breaking and crop raiding tends to become more ingrained in older bull elephants (Mutinda et al., 2011). Thus, translocating an older bull can simply shift the problem elsewhere, as documented in Sri Lanka where all 12 ‘problem elephants’ continued to be involved in human-elephant conflict after being translocated (Fernando et al., 2012). Solio (approximate age 45) demonstrated this. Eight months after being released, he started breaking fences again and spent 2% of his time in farmland that was totally new to him, most likely crop raiding. Solio did not break fences straight away, though he approached them closely and repeatedly, before eventually breaking through. This could have been due to the difference in the type of fence used in Tsavo compared to Lewa (electric fences with 1 m ‘outriggers’ vs 10–12 strand electric fences respectively). Caution about a new environment may be another explanation for Solio not immediately breaking the fence. After his first fence break in November 2018, Solio continued to break through the fence on a monthly basis, a behaviour most probably reinforced after finding familiar crops in the community farms around the base of the Taita Hills.

Solio's behaviour suggests that translocations of problem older elephants are unlikely to be the most effective and humane method to mitigate conflict between people and wildlife (Boast et al., 2016; Massei et al., 2010). Crop raiding behaviour can be a trait found in a high percent of an elephant population for both sexes. Thus, removing a few habitual raiders will not elevate the problem (Hahn et al., 2022). Moreover, fence breaking and crop raiding behaviour can be passed down from older bull elephants to younger elephants through social learning (Chiyo et al., 2011, 2012; Evans, 2015) and we must consider this when it comes to human-elephant conflict (Goldenberg et al., 2019). Thus, translocating older bull crop raiders and fence breakers does not necessarily reduce these incidents. Younger bulls in the original area may have learnt and adopted crop-raiding behaviour. Furthermore, once the translocated elephant establishes himself in a new environment and new social system, he could again start passing down these traits to new young bull elephant associates (Chiyo et al., 2011, 2012). Young adult bulls (20–25 years of age) therefore might be more suitable for translocation than older elephants (Dublin & Niskanen, 2003).

Additionally, a soft release, where elephants are held in a pen for some time prior to release, may be a way of reducing post-translocation stress and may prevent elephants from breaking electric fences (Dublin & Niskanen, 2003; Garai & Carr, 2001). Such containment may be impractical, however: two of the translocated elephants broke through electric fences, and elephants have also been known to break through boma electric fences (Garai & Carr, 2001).

4.2 | Home range, cumulative frequency and moving average

Despite a slow exploratory start by the translocated elephants, there were no significant differences between the home ranges of resident and translocated elephants after 1 year. Each individual elephant within each group (resident and translocated) had quite different home ranges from one another, highlighting the individuality of elephant movement behaviour (Wall et al., 2021). For example, the largest home range in the resident elephant group was 4549 km^2 (Kamungu), and the smallest was 1205 km^2 (Manolo). The lack of difference between home ranges of translocated elephants and residents was contrary to those of other elephant translocations, where home ranges were significantly larger in translocated elephants than residents (Fernando et al., 2012). This increased range exploration has also been seen in other translocated species such as cougars (Ruth et al., 1998) and black bears (Benson & Chamberlain, 2007).

Homing behaviour has been documented in other elephant translocations in Kenya (Pinter-Wollman, 2009); South Africa (Garai & Carr, 2001; Viljoen et al., 2015), Sri Lanka (Fernando et al., 2012) and India (Lahiri-Choudhury, 1993). Four out of five of our translocated elephants moved north during their first 3 months after translocation (the direction from where they came). Further homing behaviour may have been curtailed by the electric fence boundary of TWNP. The largest documented homing distance achieved by an elephant was approximately 300 km from an elephant translocation in South Africa (Viljoen et al., 2015).

4.3 | Group size, composition and musth

Movement in elephants relates to established social relationships (Wittemyer et al., 2007). Bull elephants that enter new areas have been shown to interact with other social groups (Evans, 2006) presumably to gather social and ecological information, vital for their survival. This social interaction of released individuals learning from residents has also been observed in other species. For example, in a study of Alpine ibex (*Capra ibex*) released individuals preferentially selected habitats that were already used by residents (Scillitani et al., 2013). We observed that translocated elephants tended to be in groups of smaller sizes than resident elephants. During July 2018 to March 2019, the translocated elephants were seen in groups with a median group size of 2, resident elephants were seen in groups with a median size of 5. This relatively low level of social interaction between translocated and resident elephants may have influenced the extent to which they explored their new environment (Goldenberg et al., 2019, 2021), as little information was gained by the translocated elephants on local resources and risk. Thus, social interactions of translocated elephants in an important driver for exploration (Goldenberg et al., 2021). The poaching of the translocated elephants Bullet and Mshauri may have been a result of being alone and not having been protected or alerted to dangers by other elephants. The fact that the translocated elephants did start to associate with other elephants towards the end of the study year is positive. Bull elephants are able to establish new strong bonds with non-relatives in the absence of family, even if this process can take many years and is harder for the older bulls (Goldenberg et al., 2016; Goldenberg & Wittemyer, 2017). Given that elephants are highly social animals and rely on sociality, elephant translocations must consider ways in which natural social behaviour can be facilitated (Goldenberg et al., 2019, 2021).

Only the translocated Saidimu and Sangare Tsavo went into musth. However, it is worth noting that Sangare only went into musth right at the end of the study period (end of February 2019). Thus, it took him nearly a year to reach this state. Four of the resident elephants were recorded in musth during the study period. Musth is energetically expensive, especially for older bulls, as musth duration and movements in musth (speed and range per day) increase with age (Poole et al., 2011; Taylor et al., 2020). The fact that only the youngest translocated bull went into musth highlights that the other elephants may not have had sufficient energy reserves to avoid the loss of body condition associated with the extra energetic cost of musth (Taylor et al., 2020). Thus, translocating older bulls could impact the reproductive dynamics and life history in a population (Taylor et al., 2020).

5 | CONCLUSION

Our study highlights the complexity of translocations for problem animal control. This translocation aimed to avoid 'problem elephants' being killed to reduce human-elephant conflict in Laikipia. However, the translocation resulted in three out of five individuals being illegally killed and one elephant causing conflict in a farming community in Taita-Taveta. Only one of the five translocated bulls, who happened to be the youngest elephant could be classified as an unqualified success, as by the end of the study year he had adapted to his new environment inside the protected area of TENP and did not continue with his old habits of fence breaking and crop raiding. The low success rate suggests that translocation is not necessarily the most effective solution for problem bulls, incurring economic costs, creating welfare concerns with a low chance of a successful outcome. Focusing mitigation management on a larger number of elephants habitual raiders will have less impact, then.

If translocation continues to be the method of choice for problem bulls, there is a need for thorough planning and sound science to inform future operations. Elephant social systems, time of release, the release habitat suitability and proximity to potential new human-elephant conflict sites should all be consciously considered with optimum conditions targeted when planning for a translocation and release. This collaborative study also highlights that every elephant will behave and react differently to a translocation, depending on its age, temperament and life experience. Post release monitoring and additional security may be important management considerations with cost implications for ensuring the health and wellbeing of translocated elephants in the future. In the long term, prevention of individuals becoming 'problem elephants' (persistent fence breakers and crop raiders) in the first place is likely to be a more effective management tactic for elephant managers, which could involve better spatial land-use planning, negative conditioning tactics and the maintenance and upgrading of barriers.

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CONFLICT OF INTEREST

None declared.

DATA AVAILABILITY STATEMENT

All data used in this research are available on request from Save the Elephants. Data especially on individual locations may be shared only by the permission from the Kenya Wildlife Service due to the sensitivity surrounding conservation of such information.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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