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Captive rearing of orphaned African wild dogs (*Lycaon pictus*) in Namibia: A case study

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Abstract

African wild dogs (AWDs; *Lycaon pictus*) are an endangered canid species facing drastic decline throughout their range due to habitat fragmentation and persecution by humans over livestock depredation, resulting in dens destroyed and adult members of packs and pups often being killed. Breeding of captive AWDs is challenging due to high juvenile mortality, only marginally improved from wild conditions, thus both in situ and ex situ conservation remains critical. As a result of human-wildlife conflict, between 2017 and 2018, the Namibian Ministry of Environment, Forestry and Tourism confiscated three litters of orphaned AWD pups from rural farmers who had destroyed the dens in Eastern Namibia and placed the pups with the Cheetah Conservation Fund. Seventeen of the 18 pups were successfully reared to yearlings with 15 individuals translocated for eventual soft release into a private game reserve. This case study provides information on the successful rearing of three litters of orphaned wild dog pups on behavior, housing, husbandry, diet, growth and medical issues as limited information is available for rearing orphaned pups from the age of 2.5 weeks old.

KEYWORDS

canid, human-wildlife conflict, husbandry, painted dog, pup

1 | STATEMENT OF THE PROBLEM

African wild dogs (AWDs; *Lycaon pictus*) are endangered canids; primarily due to habitat fragmentation (Woodroffe & Ginsberg, 1999), depleted prey (Woodroffe & Sillero-Zubiri 2012), road kills (Drews, 1995; Ray et al., 2005), human-wildlife conflict (Gusset et al., 2009) and diseases such as canine distemper and rabies (Alexander & Appel, 1994; Creel & Creel, 1998; Woodroffe et al., 1997; Woodroffe et al., 2007). Only 7% of AWD former range remains (IUCN, 2019; Woodroffe, 2011), and they are often found outside of protected areas where they are killed (Lindsey et al., 2005; Rasmussen, 1997; Woodroffe et al., 1997). As a result of human-wildlife conflict, adult AWDs are often killed and dens and pups destroyed (Gusset et al., 2009; Rasmussen, 1997; Woodroffe et al. 2005). Between 2017 and 2018, the Namibian Ministry of Environment, Forestry and Tourism confiscated three litters ($n = 18$) of wild-born, orphaned AWD pups and placed them with the Cheetah Conservation Fund (CCF) to raise (Table 1).

Captive breeding contributes to the management of free-ranging AWD populations through education, research, potential reintroduction, and increasing the size of the global gene pool (Woodroffe et al., 1997). Captive raised individuals have potential to learn how to successfully hunt and socialized appropriately when integrated with wild-raised AWDs, aiding in higher probability of successful reintroduction back into the wild (Hayward et al., 2007). However, pup mortality in captivity is high (63% at <30 days; Frantzen et al., 2001) making it difficult to ensure the longevity of captive populations (Yordy & Mossotti, 2016). In in situ populations, with a minimum of five adults or more, loss of all pups in a litter is rare (Courchamp & Macdonald, 2001; Woodroffe, 2011). Pup and juvenile

TABLE 1 Demographics of orphan African wild dog pups at arrival, and age (weeks) when groups moved to different enclosures and size of enclosures

Group	No. male	No. female	Date of arrival	Est. days of age at arrival (weeks)	Ave. weight at arrival (kg)
1	2	0	19-Jun-17	31 (4.5)	1.3 (±0.07)
2	4[a]	3	10-Aug-17	31 (4.5)	1.3 (±0.16)
3	7	2	29-Jun-18	17 (2.5)	0.73 (±0.04)

Age (weeks) moved to enclosures							
Group	Enclosure 1 nursery room/den box (7.2 ± 4.5 m^2)	Enclosure 2 outside day enclosure (51.2 ± 32.8 m^2)	Enclosure 3 outside night enclosure (14.7 ± 8.9 m^2)	Enclosure 4 larger day enclosure (257.6 m^2)	Enclosure 5 adolescent pup enclosure (1200 m^2)	Enclosure 6 Adult dog enclosure (90,000 m^2) (9 ha)	Rehabilitaion area game reserve (5 ha)
1	4.5	5	6	12.5	20.5	60	N/A
2	4.5	5.5	5.5	10	14.5	N/A	56.5
3	2.5	3.5	7.5	7.5	11.5	15.5	73.5

[a]One male euthanized due to distemper at 62 days (7.5 weeks).

mortality rates are known to vary throughout AWD geographical landscape, with low survival rate (16%) of pups reaching adulthood in Kruger National Park, South Africa, while in Botswana, 37% of the pups survived to adulthood (Creel et al., 2004), in comparison to 44% survival rate in Selous Game Reserve, Tanzania (Creel & Creel, 2002).

Limited information is available on orphaned AWD pup care (Encke, 1963; Van Heerden eta al., 1970). This case study provides information on behavior, housing, diet, growth, and medical care for three litters *(n = 18)* of orphaned AWD pups from 2.5 to 19.5 weeks of age.

2 | DESCRIPTION OF THE PROCESS

2.1 | Behavior, housing, and husbandry

The sexes and estimated ages of the three groups of pups at arrival ranged from 2.5 to 4.5 weeks, Group 1 (Gp1; 2 Males), Group 2 (Gp2; 4M, 3 Females) and Group 3 (Gp3; 7M, 2F) (Table 1). Groups 1 and 3 received more human interaction, as they were bottle raised due to smaller group size (Gp1) and young age (Gp3). Group 3 also required stimulation to help them void until 3.5 weeks old. Upon arrival, Groups 1 and 2 were vocal and excited before feeding. Pups played with siblings during the day. After the first week, pups from Groups 1 and 2 were provided with access to an outside pen during the day (Enclosure 2; Table 1) and enclosed in the indoor nursery during the night (Enclosure 1; Table 1).

Pups from Group 3 were emaciated and very weak upon arrival, waking only for feedings the first few days. In the wild, pups only start to emerge from the den around 3–4 weeks of age, although they do not fully leave the den until about 3 months of age (Thomas et al., 2006; Malcolm & Marten, 1982). The pups were housed in a den box with blankets and a constant heat source for the first week to regulate body temperature, and for the first few nights of sleeping outside (Enclosures 1 and 3; Table 1). As the pups gained strength, they started to vocalize and play with siblings.

Between the ages of 5.5 and 7.5 weeks old, all groups were permanently moved to Enclosures 2 and 3, refer to Table 1. As the pups grew, their enclosures were enlarged (Enclosures 4–6; Table 1).

Groups 1 and 2 were introduced at 12.5 and 5.5 weeks, respectively. Muzzle-to-muzzle contact from Group 1 allowed the younger pups to lick and sniff the older pups. Social twitter calls from both groups were observed. Group 1 regurgitated meat for Group 2; this behavior has been seen before and is innate (Malcom & Marten, 1982; Robbins, 2000). The pups were subsequently housed together and moved to the adolescent enclosure (Enclosure 5, Table 1). At 56 weeks old, Group 2 was moved to a rehabilitation area at a game reserve (Table 1), except for one female who remained housed with Group 1.

At the game reserve, the yearlings were separated by sex into different rehabilitation areas and were introduced to opposite sexed individuals from free-ranging packs. The use of rehabilitation areas has aided group cohesion and alpha pair establishment in artificial pack formation (Bouley et al., 2021).

At 9.5 weeks of age, Group 3 interacted through a fence with Group 1 sub-adults and one female from Group 2 (Enclosure 5; Table 1), in hopes the female and the dominate male from Group 1 would adopt the pups while the subordinate male would aid in co-operative rearing of the pups (Malcom & Marten, 1982; Riedman, 1982). Positive behavior was recorded which included immediate regurgitation from Group 1, muzzle-to-muzzle contact though the fence, and social twitter calls from all individuals. At 10.5 weeks old, after a week of fence-to-fence introduction, Group 3 was introduced to Group 1 males. Initially, positive behaviors were seen, however when the female from Group 2 was introduced, she immediately showed aggression towards Group 3 by charging and picking up the pups in her mouth and shaking them, causing minor injuries. Group 3 was immediately separated. Subsequently, the female from Group 2 was moved to the rehabilitation area at the game reserve to rejoin her siblings (Table 1). A week later, after recovering from injuries, Group 3 was successfully reintroduced to Group 1 (Enclosure 5; Table 1). The males from Group 1 laid down allowing Group 3 pups to run around and over them. These two groups stayed together for approximately a year and moved to a 9 ha camp (Enclosure 6; Table 1). The group was separated when the females in Group 3 reached sexual maturity to prevent breeding and all of Group 3 were moved to a rehabilitation area at the game reserve (Table 1).

2.2 | Diet and growth

On arrival, due to the differences in ages and overall health, the number of feedings and the amount of milk and meat given varied between the Groups (Table 2). Groups 1 and 3 received diluted (5 g powder to 15 ml of water) Milko-Pup (Kyronlabs©), milk replacement powder in addition to meat (Table 2). All three groups were fed warmed donkey (*Equus asinus*), or horse (*Equus caballus*) skeletal and organ meat with a calcium supplement (Predator Powder©, HealthTech Predator Supplement; ratio of 30 g predator powder per 4 kg of meat excluding bones). The average amount of feedings per day, meat fed per pup, and weight of the pups by week for Groups 1, 2, and 3 is shown in Figure 1a–c, with Table 2 showing the overall average diet for a single AWD.

Pups in Group 1 received diluted milk powder (Kyronlabs© Milko-Pup) from the bottle for the first week then the diluted milk was poured over the meat from 5.5 to 7.5 weeks old, after which undiluted milk powder was placed on the meat until 15.5 weeks, weaning age. Group 1 was fed warmed chicken (*Gallus gallus domesticus*) meat along with organ and red skeletal meat for the first 13 days then transitioned off chicken. Pups in Group 1 were fed individually until 12.5 weeks of age when they began group feeding with the 6.5-week-old pups from Group 2 (Figure 1a,b).

Group 2 received undiluted Milko-Pup milk powder (Kyronlabs©) on their meat for 1 week (7–8 weeks of age, until weaning) when beginning group feeding with Group 1. Group 2 was weaned from milk at an earlier age than Group 1 (13.5 weeks) and a week earlier than Group 3 (9 weeks).

Pups from Group 3 were bottle fed diluted Milko-Pup milk (Kyronlabs©) until 4.5 weeks old, after which the diluted milk was poured over the meat and fed individually to each pup (Table 2). Pups from Group 3 were fed individually until the age of 5.5 weeks old when they began feeding as a group (Figure 1c). The amount of milk powder on the meat was gradually decreased until weaning at 9 weeks of age.

At 3 weeks old, pups in Group 3 were eating on average of 22% (±20.5) skeletal meat and 78% (±20.5) organ meat per feeding, which increased, and by 4.5 weeks old, all pups (Gps1, 2, and 3) were averaging 51% (±17.8) skeletal meat and 49% (±17.4) organ meat per feeding (Table 2 and Figure 1a–c). After 4.5 weeks old, the average skeletal meat per feeding was increased from 52% to 100% (±16.8) with organ meat per feeding ranging from 0% to 48% (±16.8) (Table 2 and Figure 1a–c).

When pups were older (avg. 8.2 ± 2.1 weeks; range 6.5–10.5 weeks) and eating well, skeletal meat was given on bones (1.5–2.0 kg), which at first were "scored" so pups could easily tear meat off the bone. Gradually, all skeletal meat was given on the bone with a calcium supplement (Predator Powder©, HealthTech Predator Supplement) or as carcasses.

AWD pups were weighed on arrival and as regularly as possible thereafter to monitor growth (Table 1 and Figure 1a–c). Daily weight gain increased most from 33.5 to 67 days with an average gain of 4.41% (±4.05) per day (Table 2 and Figure 2). Weight gain was significantly positively associated with age in days across all AWD pups (Mixed-effects linear regression [Group identity random effect]: Estimate [Age] ± *SE*, 0.085129 ± 0.000906, $F = 8829$, $p < 2.2e{-}16$).

2.3 | Medical issues

All pups were dehydrated upon arrival from an extended period without food before being placed in CCF's care. Each pup was given 50 ml subcutaneous lactated ringer's injection. Groups 1 and 2 pups were dewormed at 4.5 weeks of age using oral sulfadimethoxine (Albon®, 125 mg (1/2 tab) for the first day and then 62.5 mg (1/4 tab) for Days 2–5) and fenbendazole (Panacur®, 2.5 ml for 3 days), respectively (Table 3). All Groups were vaccinated with a DA_2PP vaccine (Vanguard® Plus) against canine distemper, adenovirus Type 2 (hepatitis), parvovirus and parainfluenza, and a rabies vaccine (Merial Rabisin®), however, Group 1 received Virbac Canigen® DHPPi for their first canine distemper vaccination (Table 3).

Fecal samples from all pups were tested upon arrival for internal parasites, Group 1 had coccidia (*Cystoisospora spp.*), and no additional health issues (Table 3). At arrival, pups from Group 2 pups had hookworms (*Ancylostoma caninum*), and urine burns on their skin which were treated with germicidal barrier ointment after a bath (Table 3).

Ten days after the first DA_2PP vaccination, one male pup from Group 2 became ill with vomiting, diarrhea, a swollen jaw, facial twitching, and a limp on the rear leg. He was quarantined and treated for seven days with 5 mg of Pepcid® (active ingredient famotidine) and 8 mg Cerenia® 10 mg/ml (active ingredient maropitant citrate)

TABLE 2 Average weight and diet of African wild dog pups by age (weeks) including average number of feedings per day, average amount of milk and meat per pup, average total amount of meat per feeding, percent of skeletal vs organ meat per feeding, and additional notes on diet per group (Gp)

Age in weeks (Gp 1–3)	No. litters	No. animals	Avg. weight (±*SD*) kg	Avg. no. feedings/day (±*SD*)	Avg. ml diluted milk/pup/feeding (±*SD*)	Avg. g meat/pup/feeding (±*SD*)	Avg. total g/meat/feeding (±*SD*)	% Skeletal/organ meat/feeding	Additional notes
2.5	1	9	0.73 (0.04)	6.4[a]	11.4[a]	–	–	22/78	Individual bottle feeding (Gp3)
3.5	1	9	0.78 (0.05)	5.1[a]	18.3[a]	13.5[a]	121.3[a]	45/55	–
4.5	3	18	0.98 (0.04)	3.8 (1.0)	17.4 (7.8)	61.6 (33.7)	381.2 (307.0)	51/49	Individual bottle feeding (Gp1) Milk poured on meat (Gp2)
5.5[b]	3	18	0.73 (0.8)	3.4 (0.6)	18.2 (9.6)	100.2 (53.9)	668.6 (539.4)	52/48	Group feeding (Gp3)
6.5[c]	3	18	1.2 (1.0)	3.3 (0.5)	26.3[d]	119.7 (8.8)	1025.4 (775.6)	53/47	Milk powder sprinkled on meat. DA_2PP#1 vaccination
7.5	3	17	1.54 (1.6)	3.1 (0.1)	12.5[d]	175.1 (29.3)	1270.8 (833.0)	65/35	
8.5	3	17	1.73 (1.9)	2.8 (0.3)	[d]	236.9 (100.8)	2022.8 (1468.1)	72/28	Bones introduced
9.5[e]	3	17	2.26 (2.4)	2.5 (0.5)	[d]	330.9 (170.3)	1564.7 (1617.4)	72/28	–
10.5	3	17	2.6 (3.3)	2.6 (0.6)	–	455.3 (248.4)	2172.5 (2281.5)	61/39	Weaned off milk DA_2PP#2 vaccination
11.5	3	17	2.8 (3.8)	2.5 (0.8)	–	467.3 (164.1)	2101.2 (1978.2)	81/19	–
12.5[c]	3	17	–	2.5 (0.7)	–	483.3 (117.9)	2099.9 (1838.6)	–	Group feeding (Gp1)
13.5	3	17	–	2.4 (0.9)	–	778.1 (157.6)	2889.6 (1570.3)	–	–
14.5[f]	3	17	–	2.0 (1.4)	–	1233.4[a]	2466.7[a]	–	–
15.5	3	17	–	3[a]	–	1432.3[a]	2864.6[a]	–	Rabies vaccination
16.5	3	17	–	2.3[a]	–	1666.7[a]	3333.3[a]	–	–
17.5	3	17	–	2[a]	–	2050[a]	4100[a]	–	DA_2PP#3 vaccination

TABLE 2 (Continued)

Age in weeks (Gp 1–3)	No. litters	No. animals	Avg. weight (±SD) kg	Avg. no. feedings/day (±SD)	Avg. ml diluted milk/pup/feeding (±SD)	Avg. g meat/pup/feeding (±SD)	Avg. total g/meat/feeding (±SD)	% Skeletal/organ meat/feeding	Additional notes
18.5	3	17	–	2[a]	–	1583.4[a]	3166.7[a]	–	–
19.5	3	17	–	2[a]	–	2000[a]	4000[a]	–	–
20.5[f]	3	17	–	1.4[a]	–	–	–	–	–

[a]Data from one litter.
[b]Group 3 pups began group feeding and grams of meat consumed by individuals was no longer recorded. Individuals who did not group feed well at first were supplemented with 10 g extra skeletal meat until all pups appeared to be eating well.
[c]Group 1 (12.5 weeks) and Group 2 (6.5 weeks) begin to feed altogether, and meat eaten by individual pups in Group 1 was no longer recorded.
[d]Kyronlabs© Milk powder sprinkled on meat.
[e]Group 3 was fed large bones with meat or sections of carcasses so exact amount of food given was no longer recorded.
[f]Group 1 (20.5 weeks) and Group 2 (14.5 weeks) were fed large bones with meat or sections of carcasses so exact amount of food given individually was no longer recorded.

subcutaneously for the vomiting and 100 ml of subcutaneous lactated ringer's injection for dehydration. His health continued to decline, and he was euthanized 17 days after receiving the DA_2PP vaccination. Laboratory (Cornell Diagnostics, College of Veterinary Medicine, Cornell University, 240 Farrier Rd, Ithaca, NY), results were quantified by serum neutralizing analysis which confirmed the pup was positive for canine distemper. Blood was collected and analyzed from both Groups 2 and 3 which showed sustained protective antibody titers.

At arrival, Group 3 pups had diarrhea and two of the pups had watery, closed eyes, which were flushed with sterile water. Group 3 pups were young enough to monitor body temperatures daily. Temperatures fluctuated and stabilized at 38.5°C (Ward et al. 2006). Group 3 tested negative for parasites but were dewormed at 6.5 weeks with 0.28 ml pyrantel pamoate (Nemex®-2) for preventative treatment (Table 3), as intestinal parasites can cause severe or potentially lethal issues through obstruction of intestines in hand reared AWDs, especially when pups are young (Encke, 1963). When Group 3 was 3.5 weeks old, they received a large increase of meat which caused diarrhea and dehydration. Subcutaneous fluids (10–20 ml Ringer's lactate) with 1 ml B vitamins were given (3–5 times per day) for 2 weeks, along with oral probiotics (Pro-Well®; 0.5–1 ml per pup), once a day for 2 weeks. A germicidal barrier ointment (F10®) was used on the anus to relieve redness caused by diarrhea.

3 | DEMONSTRATION OF EFFICACY

During the first 30 days of life, AWD pups in captivity experience high mortality rates (53%–63%) (Frantzen et al., 2001; Yordy & Mossotti, 2016), with pup mortality decreasing to 44% between 4 and 10 months of age (Maddock & Mills, 1994) as pups become less vulnerable and more capable to withstand a range of environmental conditions. In the wild, high pup mortality rates are also common, with pup survival being correlated to low rainfall, pack size, geographic location of the pack, and the age of the breeding female (Buettner et al. 2007; Creel et al., 2004; Marneweck et al., 2019b).

Three litters of AWD pups in this study grew well indicating the diet and feeding regime used was effective (Figure 1a–c and Table 2). The importance of gradually increasing the amount of meat fed to pups between 3.5 and 5.5 weeks old was demonstrated with Group 3, which showed intestinal problems because of too fast meat increase. It is unclear as to why one AWD pup in this study died from canine distemper 17 days after receiving a DA_2PP vaccine. Similar results have been previously recorded in vaccinated wild AWD pups using a modified live vaccine (Durchfeld et al., 1990; McCormick, 1983; Van Heerden et al., 1989). However, previous research has shown the use of a killed vaccine to cause a lack of neutralizing antibody titers to canine distemper which provides no immunity for vaccinated individuals (Van de Bildt et al. 2002).

Introducing younger pups to known or unknown older individuals can be risky. Despite positive interactions through a barrier, the female from Group 2 was aggressive when allowed free contact with

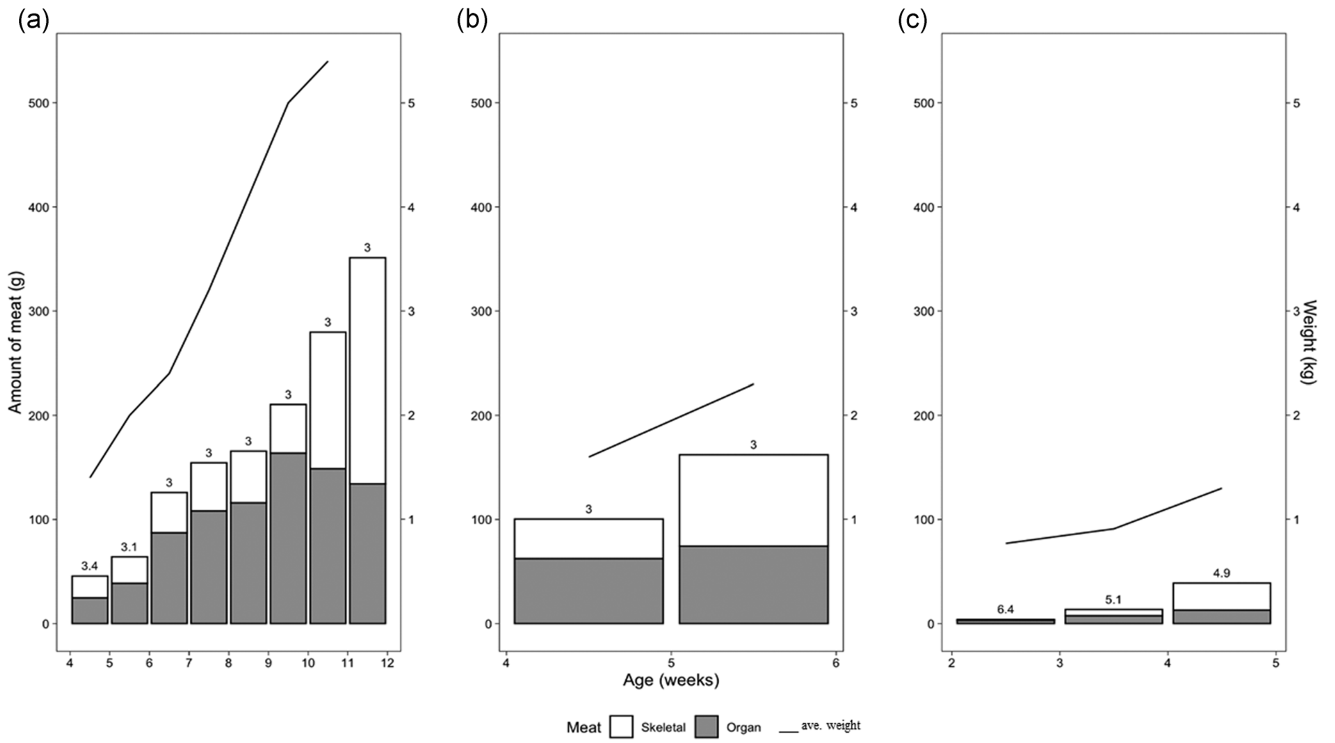

FIGURE 1 (a–c) Average meat fed per group feeding (a: Group 1; b: Group 2; c: Group 3.) for orphan African wild dogs. Numbers above the bars represents the total number of feeds per day and bar colors (grey/white) correspond to the percentage of skeletal and organ meat fed. The average weight of pups is indicated with the line. †Skeletal meat switched to being given off bones ‡Groups 1 and 2 merged feedings

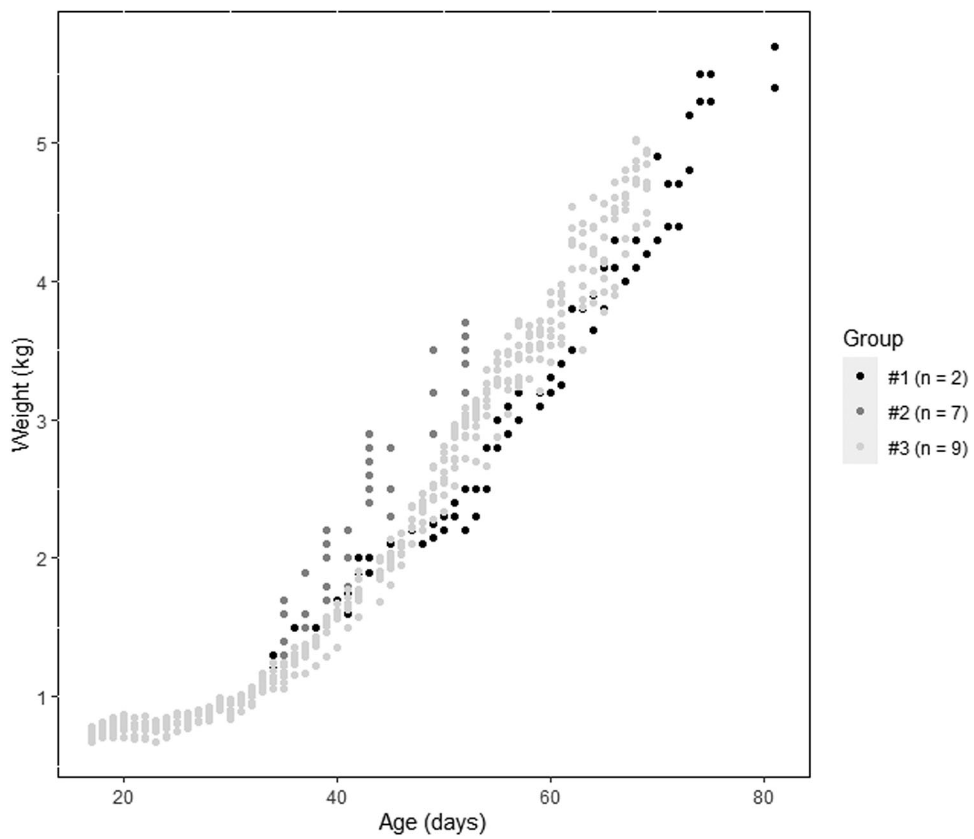

FIGURE 2 Linear regression of average daily weights of orphan African wild dog pups in Groups 1, 2, and 3, from 10 to 80 days old

TABLE 3 Deworming and vaccination regime for orphaned African wild dog pups

Group	Dewormer administered Age of pups (weeks)	Parasite type	Active ingredient	No. days given	Dosage
1	4.5	Coccidia	Sulfadimethoxine	1	125 mg
				2–5	62.5 mg
2	4.5	Hookworms	Fenbendazole	3	2.5 ml
3	6.5	Negative	Pyrantel pamoate	1	0.28 ml
Group	**Age (weeks) vaccine administered 1st DA$_2$PP**	**2nd DA$_2$PP**	**3rd DA$_2$PP**	**4th DA$_2$PP**	**Rabies**
1[a]	5.5	8.5	11.5	n/a	11.5
2[b]	6.5	11	15.5	n/a	15.5
3[c]	7.5	10.5	24	27	19

Note: Pups were vaccinated against canine distemper using a modified live Canine Distemper Adenovirus Type 2 Parainfluenza-Parvovirus (DA$_2$PP) and inactivated Rabies vaccine.

[a]Batch No.—1st vaccine—5Y2PVERV, 2nd vaccine—167994A, 3rd vaccine—167994A + 188256, Rabies—L431979.

[b]Batch No.—1st vaccine—188256, 2nd vaccine—224595, 3rd vaccine—224595, Rabies—L431979.

[c]Batch No.—1st vaccine—277884B, 2nd vaccine—268808, 3rd vaccine—288513, 4th vaccine—288513, Rabies—L45278.

the younger Group 3 pups. Similar behaviors were observed in other AWDs where hand-reared pups were reintroduced to their parents and seemingly accepted at first but were all later killed by the parents and found dead due to trauma (Van Heerden et al., 1996). Primary introductions of young pups to older individuals are thus likely safer through a barrier where individuals can only see one another and have no physical contact to assess behaviors of both groups. Introductions of new groups should be heavily monitored with means of separating groups if necessary.

Of the three groups of AWD pups raised by CCF, 15 individuals (Groups 2 and 3) were relocated to a rehabilitation enclosure at a private game reserve when they were approximately 1 year old (Table 1) for potential rehabilitation into the wild. Group 1 was unable to be considered for rehabilitation as they were too habituated. Past efforts to rehabilitate of AWDs back into the wild has performed poorly with limited success (Davies-Mostert et al. 2009; Gusset, 2009; Marneweck et al., 2019a). However, successful rehabilitation of AWDs is possible through reintroductions with socially integrated individuals into protected fenced areas to prevent conflict with humans and intensive conservation strategies (Gusset et al., 2008; Nicholson et al., 2020).

4 | CONCLUSIONS

Three litters of AWDs were raised to yearlings after being orphaned at a young age (2.5–4.5 weeks old) from human-wildlife conflict. Yearlings were then transferred to a rehabilitation area, within a game reserve and introduced to free-ranging packs. Prerelease bonding between artificial pack members while housed in a rehabilitation area, is essential to ensuring higher success rate of AWD rehabilitation back into the wild (Bouley et al., 2021). Although, the reintroduction of AWDs into the wild is complicated and captive individuals have not fared well in the past (Marneweck et al., 2019a) proper care of captive wild-born AWDs and intensive conservation strategies, can result in aiding an endangered species and have the potential to sustain a country's entire population of AWD (Houser et al., 2011; Nicholson et al., 2020).

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DATA AVAILABILITY STATEMENT

Data available on request from the authors The data that support the findings of this study are available from the corresponding author upon reasonable request.

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