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Efficacy of SAD (Berne) Rabies Vaccine Given by the Oral Route in Two Species of Jackal (*Canis mesomelas* and *Canis adustus*)

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ABSTRACT: Eight black-backed jackals (*Canis mesomelas*) and seven side-striped jackals (*Canis adustus*) were given SAD (Berne) rabies vaccine by direct oral instillation. Three different vaccine doses were used: $10^{6.3}$, $10^{6.8}$ and $10^{7.5}$ median tissue culture infectious doses. Two additional jackals were given vaccine in chicken heads. One group of jackals was challenged with a lethal dose of jackal-derived rabies virus 1 mo after vaccination and a second group 12 mo after vaccination. All 17 vaccinated jackals developed high and persistent serum neutralizing antibody titers. All challenged jackals resisted a lethal dose of rabies virus, whereas three control jackals given the same challenge succumbed to rabies.

Key words: Rabies, jackal, *Canis mesomelas*, *Canis adustus*, oral vaccination, Zimbabwe.

Two species of jackal occur in Zimbabwe: the black-backed jackal (*Canis mesomelas*) and the side-striped jackal (*C. adustus*). They appear to be equally important in rabies transmission (Foggin, 1988). Rabies has been present in Zimbabwe since 1950 when it was introduced by stray dogs from Botswana and the Republic of South Africa (Foggin, 1988). Dogs were the only significant vectors of the disease until 1966 when a large epizootic occurred in jackals. Two other large epizootics subsequently occurred in jackals. Between epizootics, sporadic cases of rabies in jackals are reported every year. Altogether jackals have accounted for almost 25% of confirmed rabies cases diagnosed in Zimbabwe since 1950 (Bingham, 1993). Rabies in jackals has been reported in many other African countries, but the jackal appears to be a major vector of rabies only in southern Africa (Foggin, 1988).

The feasibility of oral vaccination against rabies first was demonstrated in foxes (*Vulpes vulpes*) (Baer et al., 1971). Following the success of oral vaccination to control fox rabies in Switzerland in the early 1980's (Wandeler, 1988) and more recently in other European countries (Wilhelm and Schneider, 1990; Brochier et al., 1991), its use has been considered for the control of rabies in jackals in Zimbabwe. Our objective was to test the efficacy of oral vaccine in jackals.

Seed virus of the Berne strain of Street Alabama Dufferin (SAD (Berne)) strain of rabies vaccine and Baby Hamster Kidney-21 (BHK-21) cells were obtained from the Swiss Rabies Centre, Berne, Switzerland. The vaccine virus was grown on BHK-21 cells at the Veterinary Research Laboratory, Harare, Zimbabwe. This was done by inoculating working seed virus onto cells while in suspension and allowing the cells to form an almost confluent monolayer before passing. The infected cells were passed twice to fresh cells at 24 to 36 hr intervals before the media were harvested for use as vaccine. The vaccine was titrated on BHK-21 cells.

Twelve black-backed jackals and eight side-striped jackals were captured from the wild. Adults were caught using leg-hold traps (Victor Soft Catch, Woodstream Corporation, Lititz, Pennsylvania, USA) and pups were removed from dens and hand-reared. At the start of the trial all jackals were adults or sub-adults and in good health. With the exception of the feeding of the chicken head baits, all procedures on the jackals were performed under general anesthesia. For vaccination, both spe-

cies were anesthetized using ketamine hydrochloride (Ketalar, Warner-Lambert, Retreat, Republic of South Africa) given intramuscularly at a dose of 5 to 6 mg/kg. Vaccine administration was carried out during the recovery phase when the swallowing reflex was present, to minimize vaccine contact with the respiratory mucosa. For bleeding and swabbing, the following drugs, given intramuscularly, resulted in the best anesthesia: ketamine (12 mg/kg) for black-backed jackals and a combination of ketamine (7.5 mg/kg) and xylazine (1.5 mg/kg) (Rompun, Bayer, Leverkusen, Germany) for side-striped jackals.

One milliliter of vaccine with either $10^{6.3}$, $10^{6.8}$ or $10^{7.5}$ median tissue culture infectious doses per milliliter ($TCID_{50}$/ml) of virus was given by direct oral instillation to each of eight black-backed and seven side-striped jackals. Each of two other black-backed jackals consumed one chicken head bait that contained a Berne Type IV vaccine blister (Steck et al., 1982) filled with 2 ml of vaccine fluid with a titer of $10^{7.5}$ $TCID_{50}$/ml. Both jackals consumed the baits rapidly, but with thorough chewing.

To test for vaccine virus replication in the oral mucous membranes (Wandeler, 1988), and therefore the potential for unwanted transmission of vaccine virus to other animals, salivary swabs were taken 1, 3, and 7 days, respectively, after vaccine administration or baiting by the method described by Foggin (1988); suspensions prepared from the swabs were tested for virus content by intracerebral inoculation of weaned laboratory mice. Blood samples were taken from each vaccinated jackal by jugular venipuncture at the time of vaccine administration, 14 and 30 days later, and thereafter at monthly intervals until 6 mo after challenge. Serum was analyzed for neutralizing antibody in a tissue culture system as described by Zalan et al. (1979) with the following modifications. Each of the test and control sera were diluted five-fold, starting at a dilution of 1:10. Twenty microscopic fields at a magnification of ×250 were read per well. Titers were converted to International Units per milliliter (IU/ml) by titrating concurrently an antibody standard of 2 IU/ml and using the formula:

$$\text{Number of IU/ml} = (T_{serum}/T_{standard} \times 2$$

where T_{serum} and $T_{standard}$ are the 50% endpoint titers of the test serum and antibody standard, respectively, and 2 is the value in IU/ml of the antibody standard.

Of the jackals given the vaccine by direct oral instillation, eight (four black-backed and four side-striped) were challenged with rabies virus 1 mo after vaccination and six jackals (three black-backed and three side-striped) were challenged 12 mo after vaccination. One black-backed jackal, given $10^{6.3}$ $TCID_{50}$ of vaccine, died of anesthesia-related causes 8 mo after vaccination, before it was challenged. Of the jackals fed the vaccine in baits, one was challenged at 1 mo and one at 12 mo after vaccination. The challenge virus was derived from the salivary gland of a field rabies-positive black-backed jackal. Two thousand median mouse intracerebral lethal doses ($MICLD_{50}$) (Foggin, 1988) were injected into the masseter muscle. The jackals were observed daily for 6 mo after challenge.

Two unvaccinated black-backed jackals were used as controls for the 1 mo challenge and one side-striped jackal was used for the 12 mo challenge. Each of the controls were captured from the wild as adults and housed in isolation starting from the commencement of the trial. They were bled after capture and at the time of injection with the challenge virus to confirm the absence of detectable antibodies.

No jackals had detectable neutralizing antibody titers at the start of the trial. All vaccinated jackals developed neutralizing antibodies; most had high and persistent levels (Table 1). All vaccinated jackals resisted the challenge virus. Both jackals fed vaccine in bait developed high titers (4.5 and 8.5 IU/ml at 1 mo) and both resisted

the challenge virus. In all groups, post-challenge vaccinal titers were similar to or higher than pre-challenge titers; the greatest post-challenge antibody response occurred in a side-striped jackal which developed a titer of 105 IU/ml 1 mo after challenge. The three controls died from rabies 15, 16 and 17 days, respectively, after challenge. Virus was not isolated from any of the saliva swabs following vaccine administration nor from the brain of the jackal which died as a result of anesthesia.

The SAD (Berne) vaccine and its derivatives, given by the oral route, have proven their efficacy in red foxes (*Vulpes vulpes*) (le Blois et al., 1990), arctic foxes (*Alopex lagopus*) (Follmann et al., 1988), raccoon dogs (*Nyctereutes procyonoides*) (Nyberg et al., 1992), and domestic dogs (Blancou et al., 1990). To our knowledge, this is the first report of successful oral rabies immunization of black-backed and side-striped jackals.

Apart from being effective in inducing immunity in the target rabies vectors, oral rabies vaccines should be safe by the oral route in non-target bait-consuming species (Wandeler, 1988). The SAD virus is pathogenic by the oral route in various rodent species and occasionally other mammals (Wandeler, 1988). The SAD (Berne) vaccine virus also is pathogenic in chacma baboons (*Papio ursinus*) (Bingham et al., 1992), a prominent bait-consuming primate. As this species is abundant in most areas of Zimbabwe and will readily consume baits, the SAD (Berne) vaccine has been rejected as a candidate for potential field use. The trial in jackals described here was begun before the finding of the pathogenicity of SAD (Berne) in baboons, and thus it was continued to its termination. Our findings, however, can be used as baseline data for other rabies vaccine efficacy trials. Other oral vaccines will need to be tested in order to identify a safe vaccine for non-target species.

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TABLE 1. The vaccine doses in $\log_{10}$ median tissue culture infective doses ($TCID_{50}$) given by the oral route, and the pre-challenge mean serum neutralizing antibody titers in International Units per milliliter (IU/ml), of black-backed and side-striped jackals.

Vaccine dose ($TCID_{50}$)	Interval after vaccination in days			
	14	30	183	365
Black-backed jackals				
6.3	0.1 (2)[a]	7.7 (2)	15.0 (1)	ND[b]
6.8	6.7 (2)	13.6 (2)	13.7 (1)	13.2 (1)
7.5	8.5 (4)	15.3 (4)	5.8 (2)	3.8 (2)
Side-striped jackals				
6.3	0.2 (1)	0.7 (1)	ND[b]	ND
6.8	1.1 (2)	2.9 (2)	3.5 (1)	1.8 (1)
7.5	2.9 (3)	6.9 (4)	5.2 (2)	2.2 (2)

[a] Mean serum neutralizing antibody titers in IU/ml (sample size).
[b] Not done.

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