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RESEARCH ARTICLE

Success of captive breeding and a hormonal trial to increase the reproductive efficacy of Arabian Tahr, *Arabitrgus jayakari*

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ABSTRACT

This is the first study to show the results of the breeding of Arabian Tahr, *Arabitrgus jayakari*, with a hormonal attempt to increase its reproductive efficacy in captive breeding unite. Data of reproductive success of a small population of Arabian Tahr kept in a protected area of Wadi Wurayah, Fujairah, was summarized from 2018-2022. The pregnancy rate, which was around 90% in the first three breeding seasons, decreased to 66.7% in the last breeding season. The rate of late abortion and/or stillbirth in all breeding seasons was between 11-25%. No multiple births or abortion of fetuses were observed during the four recorded breeding seasons. A hormonal trial was performed in the last breeding season 2021-2022 to synchronize the estrus and increase the reproductive efficacy. Eighteen parous females and 9 adult males were randomly mixed and divided into three groups: two treatment groups and a control group (G3; n = 6). Females were treated with an intravaginal sponge impregnated with 30 mg of Flurogestone acetate (FGA) for either fourteen (G1; n = 6) or seven (G2; n = 6) days, respectively. At the sponge removal, females of the G1 and G2 groups received intramuscular injections of 200 IU of eCG and 75 μg of Cloprostenol. The pregnancy rate was higher in G2 compared to the other two groups and it was also higher in G1 than in G3. The lambing rate was 100% in the control group, and it was higher in G2 compared to G1. The rate of estrous synchronization was similar in both treated groups. In conclusion, Breeding of Arabian Tahr in captivity can be improved by estrous synchronization and induction of ovulation early in the breeding season by using short-term progestagen treatment followed by eCG injection. More research on other doses of eCG and the nutritional requirements are required to increase the reproductive efficacy of Arabian Tahr in captive breeding.

Keywords: Arabian Tahr; Reproduction; Captivity; Hormonal stimulation

INTRODUCTION

Arabian Tahr (*Arabitrgus jayakari*) is a native wild caprid endemic to the Hajar Mountains between the UAE and Oman (Ross et al., 2019). Overgrazing, poaching, predation, climate change and habitat destruction in the steep, rocky natural habitat leaded to their endangerment (Edmonds et al., 2006; Ross et al., 2017). Arabian Tahr is a seasonal breeder mostly from September to November with sometimes a second rut occurs in February and March in years when there is good forage after early rainfall (Wood, 1992). Unlike other caprid species, the Arabian Tahr reproduces in small, dispersed family units, each of 1-2 females with a single male (Korshunov, 2016). During the last 3 decades, some captive breeding programs were set up in Oman and UAE to protect, increase, and reintroduce the captive-bred individuals back to the wild (Korshunov, 2016).

Arabian Tahr has low reproductive efficacy compared to the domestic caprid species (Korshunov, 2016). However, some research was done to protect and conserve these endangered animals and their natural habitats (Ross et al., 2017 & 2021), but no studies were done to improve the fertility and increase the number of lambs per female of Arabian Tahr in captivity. In domestic sheep and goats, increasing the reproductive efficacy through estrous synchronization, induction of multiple ovulations and increasing the conception rate and the percentages of multiple births is routinely used (Abecia et al., 2012). Intravaginal devices of either progesterone CIDR (Controlled Internal Drug Release) or progestagens sponge impregnated with fluorogestone acetate (FGA) or medroxyprogesterone acetate (MAP) associated with injection of equine chorionic gonadotrophin (eCG) near

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the end of progesterone treatment (P4-eCG) is the widely applied technique (Hameed et al., 2021). Traditionally, a long-term (12-14 days) P4-eCG was used, a period like the lifespan of a cyclic corpus luteum, regardless of the stage of the cycle or the follicular activity on the ovaries at the time of treatment initiation (Killian et al., 1985). More recently, a short-term P4-eCG treatment (6-7 days) results in a series of benefits like better control of follicular response and ovulation (Menchaca et al., 2017). The current study is addressed to: (a) Summarize the reproductive data from 2018-2022 of a small population kept in captivity in a protected area of Wadi Wurayah, Fujairah, UAE; (b) Test the effect of both long-term and short-term P4-eCG on estrous synchronization and reproductive efficacy in Arabian Tahr, *Arabitrgus jayakari*.

MATERIALS AND METHODS

Animal care and nutrition

Because of the aggressive behavior of male Arabian Tahr, females and males were kept separately outside the breeding season in protected bounded mountainous areas. They were mixed shortly after the middle of August every year and separated again at the end of November. Animals were fed ad libitum on special pellets of Gazella (16% protein, 2% Crude Fat, ADF 30%, NDP 45%- National Feed, Abu Dhabi, UAE), dried Alfa Alfa and Rhodes grass. Additionally, each animal was provided daily with 100- 200 g of fresh sidr, *Ziziphus spina-christi*, leaves.

Experimental design and animal groupings

Data on the breeding success of Arabian Tahr in four years were collected and analyzed. In the last breeding season 2021-2022, eighteen parous females (BW 16 ± 2 kg) and 9 adult males (BW 34 ± 3.5 kg) with the age of 3-6 years were included in the experiments. Shortly before the onset of the experiment, a feed mix of 50% wheat bran, 25% crushed barely and 25% corn flakes supplied with multivitamins (Oligovit Plus, VMD Livestock Pharma, Belgium), 20:1 (w: w) was added to the experimental animals in addition to the above-mentioned feeding staffs. Circa 10 and 20 g. were daily supplied for each female and male, respectively.

Starting from the 25th of August 2021, males and females were transferred to the breeding enclosures (Fig. 1), divided randomly and mixed in three groups and each group contained 6 females and 3 males. Each group was subdivided into 3 sub-groups, each of two females and one male. Each sub-group was kept in an enclosure composed of two compartments; a small compartment of 150 m^2 which was encircled with a larger one of 500 m^2 with a connection door in between. Firstly, the male was kept in the small compartment and the two females were in the large compartment. After two weeks, the door in between the two compartments was opened and let the male unite with the females (Fig. 2). On the 12th and 15th of September, 2021, females were caught and treated with an progestagens intravaginal sponge (PIVS) impregnated with 30 mg of Flurogestone acetate (FGA- Syncropart®, Ceva Santé Animale, France) for either fourteen (G1; n = 6) or seven (G2; n = 6) days, respectively (Gonzalez-Bulnes et al. 2005; Martinez-Ros et al. 2019). At the sponge removal, females of G1 & G2 groups received intramuscular injections of 200 IU of eCG (Novormon, Syntex S.A., BUENOS AIRES, Argentina), and 75 μg of Cloprostenol, a synthetic analogue of prostaglandin, PG (Bioestrovet®, Vetoquinol, Cedex, France). The prostaglandin ($PGF_2\alpha$) treatment was designed to eliminate any active corpus luteum at sponge withdrawal. A control group (G3; n=6) was kept under similar conditions without receiving any hormonal treatment. Both sexes were kept under observation without touching, to avoid any stress and separated end of November 2021.

Fig 1. Breeding enclosures of Arabian Tahr in Wadi Wurayah, Fujairah, UAE.

Fig 2. A male and 2 females Arabian Tahr in a breeding enclosure, after opening the door in-between the two compartments.

Treatment response

The date of birth or late abortion for each female was recoded. For each group, the number of abortions and/or stillbirths, or normal lambing were counted. Pregnant females were counted as the number of lambed females + the number of aborted females.

The period elapsed, in days, from the removal of the vaginal sponge till the birth of each female from G1 and G2 was calculated to be able to calculate the rate of estrous synchronization. The rate of synchronized estrous of the two hormonally treated groups was calculated from the number of females who gave births after 174 ± 3 days from the date of sponge removal to the total number of lambed females within each group.

Statistical analysis

The pregnancy rate was according to the following:

$$\frac{\text{No of lambed} + \text{No of aborted}}{\text{Total number of mated females}} \times 100$$

Results expressed as percentages were performed after angular transformation (arcsin $\sqrt{p}$) of the values for each individual percentage. Inter-group differences in binomial variables (rates of fertility and days from mixing both sexes till birth) were assessed for significance using one-way ANOVA with subsequent Duncan test. Chi-squared analyses was used to compare the differences in estrous synchronization between the treated G1 and G2 groups. The results are represented as mean ± SD and the differences were considered significant at a probability level of $P<0.05$. All statistical analysis were done using SPSS® 22 for Windows® (SPSS Worldwide Headquarters, Chicago, IL, USA).

Fig 3. Male and female courtship after the removal of PIVS and injection of eCG and $PGF_2\alpha$.

RESULTS

Reproductive parameters

The pregnancy rate was around 90% in the first three breeding seasons and significantly decreased ($P<0.05$) to 66.7% in the fourth breeding season (Table 1). The rate of late abortion and/or stillbirth and newborn vitality in all breeding seasons were in the range of 11-25 % and 75-90 %, respectively. The third breeding season showed a lower rate of late abortion and/or stillbirth and a higher percentage of newborn vitality ($P<0.05$) compared to the second breeding season (Table 1). No multiple births or multiple abortions were observed and recorded in Wadi Wurryah during all four breeding seasons.

Hormonal experiment

All the females treated with long-term progestogens treatment (G1) showed a copious mucoid or purulent vaginal discharge at the sponge withdrawal. The courtship behavior followed by copulation was started after about 24 hours from the removal of PIVS and injection of eCG and $PGF_2\alpha$ (Fig. 3). Pregnancy rate was higher ($P<0.05$) in G2 (100.0 %) compared to the other two groups and it was also significantly higher ($P<0.05$) in G1 (83.3 %) than in G3 (50.0 % -Table 2). However, there was no late abortion and/or stillbirth in the control group, it was higher in G1 (40.0 %) than in G2 (16.7 % -Table 2). Lambing rate was 100.0 % in the control group and also was higher ($P<0.05$) in G2 (83.3 %) compared to G1 (60.0 % -Table 2). The rate of estrous synchronization did not show a significant difference between the females of the groups G1 and G2 (Table 2). From our experiments, only 2 and 3 lambs were born in March 2022 from G1 and G2, respectively with an average of 174.6 ± 2.1 days from the date of P4 sponge withdrawal. However, 1, 2, and all the three lambs from the G1, G2, and G3 groups, respectively, were born in April 2022.

Table 1: Breeding success (actual number/percentage) data from 2019-2022 of Arabian Tahr in Wadi al-Wurayah, Fujairah, UAE

Breeding season/Year	Number of breeding F	Pregnancy	Late-term abortion &/or stillbirth	newborn vitality
First (2018-2019)	15	14 (93.4)^{a}	3 (21.4)^{a,b}	11 (78.6)^{a,b}
Second (2019-2020)	18	16 (88.9)^{a}	4 (25) ^{a}	12 (75.0)^{b}
Third (2020-2021)	20	18 (90.0)^{a}	2 (11.1)^{b}	16 (88.9)^{a}
Fourth (2021-2022)	24	16 (66.7)^{b}	3 (18.8)^{a,b}	13 (81.3)^{a,b}

Values within a column with different superscripts are significantly different (P<0.05)

Table 2: Estrous synchronization and breeding success in different groups of Arabian Tahr. G1: PIVS for 14 days followed by injection of eCG and PGF2α; G2: PIVS for 7 days followed by injection of eCG and $PGF_{2\alpha}$; G3: control group

Parameters N (%)	Treatment groups		
	G1	G2	G3
Pregnancy	5/6 (83.3%)[b]	6/6 (100.0%)[a]	3/6 (50%)[c]
Late-term abortion &/or stillbirth	2/5 (40.0)[b]	1/6 (16.7)[a]	0/3 (0.0%)[c]
Lambing	3/5 (60.0)[a]	5/6 (83.3)[b]	3/3 (100.0)[c]
Estrous synchronization	2/3 (66.6)[a]	3/5 (60.0)[a]	-

Values within a raw with different superscripts are significantly different ($P<0.05$)

DISCUSSION

This is the first study that discussed the results of Arabian Tahr breeding in captivity. Arabian Tahr is a wild mountainous caprid species (Ropiquet and Hassanin, 2005) with a total population estimate of 2,446 individuals (Ross et al. 2019). Since 1986, it was assessed as an endangered species according to the Red List Criteria of the International Union for Conservation of Nature (IUCN). Therefore, many attempts have been done in Oman and UAE to protect this species by breeding in captivity and reintroduce to the wild life (Korshunov, 2016). Naturally, Arabian Tahr, like other wild caprid species, live separately most of the year into exclusive male flocks, and flocks of females with their young lambs (Lindsay, 1988). Shortly before the breeding season, they reunite together in small groups, each of 1 male with 1-2 females (Korshunov, 2016). Our data in captive breeding in Wadi Wurayah, Fujairah, from 2018-2022 showed that the pregnancy rate was almost circa 90% with exception of the last breeding season (2021-2022), In which the pregnancy rate dropped to 66.7%. The main reason for this sharp drop is unknown which might be due to environmental, nutritional, infectious or inbreeding with a loss of genetic diversity within our small population. Inbreeding leads to a reduction in the flexibility to adapt the future threats such as disease and climate change (Frankham et al., 2014).

The rate of late abortion and/or stillbirth in all breeding seasons was between 11-25%. However, this rate was not high and within the range of other studies in domestic sheep and goats (Clune et al., 2022), the etiology of this phenomenon in Arabian Tahr needs further veterinary and laboratory investigations. In sheep and goats, there are several causes of late abortion and/or stillbirth involving infectious diseases, weather conditions, feed shortage, physical traumas, and plant poisoning (Alemayehu et al., 2021).

The pregnancy rate was higher in both hormonally treated groups than in the control group. However, lambing rate was lower and the rate of late abortion and/or stillbirth were higher in G1, as a long-term 14 days progestagen treatment than in G2 as a short-term progestagen treatment. To increase the reproductive efficacy and the rate of multiple births in sheep and goats, insertion of a progestagen impregnated intravaginal sponge, followed by equine chorionic gonadotrophin (eCG) injection is an applied technique (Abecia et al., 2012). Our results showed that short-term progestagen treatment of 7 days was superior in the rates of pregnancy, and lambing compared to long-term treatment of 14 days. Similarly, the short-term protocols offered similar or better fertility rates than long-term treatments in domestic sheep (Martinez-Ros et al., 2019). The explanation of the lower fertility of long-term progestagen treatment may be due to very little progesterone being released from the sponge at the end of the insertion period which might affect the ovulation quality (Gonzalez-Bulnes et al. 2005). Also, long-term progestagen treatment was associated with abnormal vaginal discharges at sponge withdrawal which enforces previous studies in sheep reporting that long-term progestagen treatments are always associated with vaginitis, soaking of the polyurethane sponge, and retention of vaginal mucopurulent or bloody secretions (Martinez-Ros et al., 2018). Short-term progestagen treatment of 6-7 days protocol was previously developed (Knights et al., 2001) which is shorter than the half-life of a corpus luteum in the ovary. Therefore, corpus luteum lysis should be induced using a single dose of prostaglandin F2α or its synthetic analogues (PG) at sponge insertion or removal (Cox et al., 2012).

From our experiments, 60 and 66.6% of born lambs, as the rate of estrous synchronization, were born in March, 2022 from G1 and G2, respectively within 174.6 ±2.1 days from the date of the sponge withdrawal. But all three lambs (100%) from the control G3 group were born in April. The normal gestation period in Arabian Tahr is 168-172 days and lamb survival is higher during the cooler months of late February to early April (Korshunov, 2016). Early estrous synchronization and mating in the breeding season have an advantage in that lambing happens during the cooler months of late February and March. Female lambs born during this period are mature (≥1.5 years old - Korshunov, 2016) and can be bred early during the breeding season of the next year. Additionally, non-pregnant or missed females from the first estrous synchronization and mating during September can be mated during the second rut in February or March (Wood, 1992). However, twin birth in Arabian Tahr was previously recorded in the wild and in the territory of Jebel Hafeet, Al-Ain, Abu Dhabi (Korshunov, 2016), there were no twins, multiple births, or even abortion of more than one fetus in Wadi Wurayah. This is might be due to the weak genetic variability in the exciting small population of Wadi Wurayah or other keeping and nutritional factors.

Additionally, in our hormonal trial, only one dose of eCG (200 IU/female) to induce multiple ovulations in Arabian Tahr was tested. The dose of eCG varies from 200 to 750 IU in sheep (Boland et al., 1981), and higher doses (up to 1000 IU) are required in goats depending mainly on age, weight, season and breed (Abecia et al., 2012). Another factor that plays a major role in the reproductive performance of small ruminants is the nutritional requirements (Somchit et al., 2007). The relationship between ovary functioning and nutrition is a fundamental rule to maximize reproductive efficiency (Rondina et al., 2005). Our trial to flush the Arabian Tahr with some concentrates supplemented with some vitamin and minerals did not improve the fertility. Arabian Tahr, as a wild small ruminant, depends naturally in their feeding on some mountainous plant leaves, bark, seeds, and fruits in the diverse vegetation. Therefore, further studies are required to test higher doses of eCG and to determine the exact nutritional requirements, to formulate a proper diet, for improving the reproductive efficacy of Arabian Tahr in captivity.

CONCLUSION

Breeding of Arabian Tahr in captivity can be improved by estrous synchronization and induction of ovulation early in the breeding season by using short-term Progestagens treatment followed by injection of eCG. More research on other doses of eCG and the nutritional requirements are required to increase the reproductive efficacy of Arabian Tahr in captive breeding.

Declaration of competing interest

The author declares that there is no conflict of interest. The funding sponsor had no role in the design of the study, collection, analyses, and interpretation of data, writing of the manuscript, and to publishing of the results.

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Ethics approval

The hormonal experiment was approved by Fujairah Environment Authority, Government of Fujairah, which was done by the regulations of the International Union for Conservation of Nature (IUCN).

Author contributions

Nabil Mansour: Methodology, investigations, statistical analysis, revision, writing and editing. Vladimir M. Korshunov: collection of data, helped to set the experimental design and helped in the practical part. Praveen Pankajakshan: helped and followed up the practical experimental part.

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