STUDBOOK OF

WESTERN TRAGOPAN

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Tragopan melanocephalus

Data till August, 2011

Produced as a part of the ongoing project on
Reproductive Biology and Behavior of Captive and Wild Populations of Western Tragopan in Himachal Pradesh

Principal Investigator
Dr. K. Ramesh
Scientist – C, Wildlife Institute of India

Co-Investigator
Dr. Parag Nigam
Scientist – D, Wildlife Institute of India

Research Fellows
Mr. Lakshminarasimha R.
Ms. Samhita Bose

Collaborators
Mr. Ashwanii Gulaati
Chief Wildife Warden, Himachal Pradesh

Mr. Sanjeeva Pandey
Chief Conservator of Forests (Fauna and Protected Area), HPFD

Mr. Sat Pal Dhiman
Nodal Officer, Pheasant Breeding Programme, HPFD

Dr. Sandeep Rattan
Wildlife Veterinary Officer, HPFD

Photo credit:
Ramesh K
Sat Pal Dhiman
Lakshminarasimha R
John Corder

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Foreword

I have great pleasure in presenting the Studbook on Western Tragopan kept in captivity in Himachal Pradesh. This Studbook provides a brief outline of taxonomy, biology and status of this beautiful, threatened bird and then details profile of each bird at Sarahan Pheasantry, Shimla District.

Preparing a detailed profile of individual is the first step for initiating a conservation breeding programme of a species. In this context, this Studbook provides a launching pad for conservation breeding of Western Tragopan to meet the requirement of this bird in Zoos participating in its conservation breeding programme.

I hope that this Studbook which has been produced as a part of the ongoing project entitled "Reproductive Biology and Behaviour of Captive and Wild Population of Western Tragopan in Himachal Pradesh", would be a precursor for developing strategy to identify and address negative factors impinging upon conservation of this species in captivity and in the wild.

P. R. SINHA
Director, Wildlife Institute of India

September 2011

Preface

This Studbook covers the captive population of Western tragopan (*Tragopan melanocephalus*) in India. Incidentally, Sarahan Pheasantry in Himachal Pradesh is the only facility in India and also in the world to have captive stock of this species, although recently two birds from Sarahan have been transferred to Kufri Zoological Park (Himachal Pradesh) for display purpose. Anecdotal information suggest that few individuals of Western tragopan were exported to Europe in the past for captive breeding, but these birds could not be sustained on account of inadequate information on the species biology and lack of prior experience of breeding this species. Therefore, it is pertinent to emphasize that the Sarahan Pheasantry also has the distinction of having successfully bred Western tragopan in captivity anywhere in the world, when it registered hatching of three birds in the year 1993. One of these birds, a male, survived through for twelve years, indicating the potential of this breeding facility. With renewed focus and efforts, guided by the Core Group constituted for Conservation Breeding of Pheasants in Himachal Pradesh, considerable hatching successes have been achieved during the last seven years, although ensuring higher success rate to adulthood and maintaining an effective population pool continue to be major challenges. Nevertheless, the Conservation Breeding Program for Western tragopan at Sarahan Pheasantry is undoubtedly a significant step towards conservation of this species. It aims (a) to maintain a viable population size of this species in captivity, (b) to augment the wild populations and (c) to develop technical knowhow and infrastructure for conservation breeding of this species, for current and future needs.

Maintaining a Studbook is clearly a critical requirement for ex-situ management. In Sarahan Pheasantry, a total of 37 individuals of Western tragopan have been housed from 1990 until today (mid 2011), but complete pedigree is available for 22 birds. Of the remaining 15, twelve birds that were kept before 2000 did not have adequate details and for three birds, parentage could not be ascertained with certainty. However, the Studbook is not constrained by these inadequacies, given that they do not contribute to present population size in Sarahan Pheasantry; 13 are dead and two (both males) have been transferred to Kufri Zoological Park, Himachal Pradesh.

The efforts to produce this Studbook stem from one of the objectives outlined in the ongoing research project on 'Reproductive Biology and Behavior of Captive and Wild Populations of Western Tragopan in Himachal Pradesh', which is being undertaken by Wildlife Institute of India in collaboration with Himachal Pradesh Forest Department. We express gratitude to the Director and Dean of Wildlife Institute of India for making this project possible with their support and guidance.

We like to place on record the vision and commitment of the concerned people in Himachal Pradesh Forest Department for designing Conservation Breeding Program for Western tragopan, which is also 'the State Bird of Himachal Pradesh'. We thank the

Government of Himachal Pradesh, especially Mr. Avay Shukla, former Secretary for approving the project and encouragement. We acknowledge Mr. Vinay Tandon PCCF, Dr. Lalit Mohan CCF and Mr. Sanjeeva Pandey CCF for playing key roles in this collaborative efforts and scientific acumen. We are thankful to Mr. Rakesh Sood CF (Wildlife), Mr. Satish Negi, DFO (Sarahan) and Dr. Sandeep Rattan, Veterinary Officer for providing all the necessary support during the entire process. Dr. John Corder has contributed immensely to capacity building and management of Sarahan Pheasantry; we take this opportunity to acknowledge his efforts.

Compilation of the Studbook and its reliability greatly depends on the data from the captive facilities holding the animals. We are thankful to the people at Sarahan Pheasantry, for providing critical inputs regarding captive population held here. Mr. Alam Singh, Block Officer cum Pheasantry In-charge and Mr. Virender Sharma, Forest Guard were instrumental in providing the necessary data on the captive stock. The team work to produce the Studbook has been outstanding and we thank everyone for making this possible; what began as a routine documentation has now resulted in such a base document for Sarahan Pheasantry.

It is expected that the Studbook shall guide the conservation breeding programme to maintain a genetically viable population of Western Tragopan so as to act as safety net population for future. Similarly, Studbooks are also planned for other targeted species viz Cheer Pheasant and Himalayan Monal to give a boost for conservation of Pheasants in Himachal Pradesh. This joint endeavour shall greatly help in generating a sound data base and scientific information which shall ultimately lead to effective conservation strategy for the benefit of these species.

We remain grateful to all other individuals, directly or indirectly, involved during the preparation of this studbook. It is requested that all users check the data for accuracy and completeness and kindly report any inconsistencies. Studbooks are living documents and new information is constantly being added as previously unknown specimens, present or historical, are reported.

K. Ramesh, Ph.D.
Scientist-C, Wildlife Institute of India
ramesh@wii.gov.in

Ashwanii Gulaati, I.F.S.
Chief Wildlife Warden, H.P.
ashwanikumargulati@yahoo.co.in

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1 Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Aves
Order	Galliformes
Family	Phasianidae
Scientific Name	*Tragopan melanocephalus*
Species Authority	J. E. Gray, 1829
Common Name	Western Tragopan
Local Names	Jujurana (Himachal Pradesh), Fulgar, Fulgari (Chamba), Jyazi (Bashahr), Sonalu, Solalee, Jewar (Garwal), Budal (Kulu, Mandi and Suket) and Sing Monal (Hindi in NW Himalayas).

Taxonomy

2

Biology and Status

Western tragopan (Tragopan melanocephalus) is a brightly plumaged bird, endemic to northwest Himalaya, breeds in narrow altitudinal range between 2600m to 3600m in the upper temperate region. The name 'Tragopan' originated from union of the two words Tragus (goat) and Pan (half goat deity of Greek mythology). Presence of brightly coloured fleshy horns present on either side of the head of the male birds, make the birds to be known as 'Horned Pheasant'.

Currently five extant species have been recognized under the genus Tragopan;

1. Western Tragopan
   T. melanocephalus
2. Satyr Tragopan
   T. satyra
3. Blyth's Tragopan
   T. blythii
4. Temminck's Tragopan
   T. temminckii
5. Cabot's Tragopan
   T. caboti

Of these five species, four occur in the Indian Himalaya, while Cabot's tragopan is confined to China. Molecular studies suggest that events during Pleistocene and Pliocene might have fostered speciation in the genus Tragopan splitting the Himalayan population into T. melanocephalus, T. satyra and T. blythii and Chinese population into T. temminckii and T. caboti (Figure 1; Randi et al. 2000). No subspecies has been described for Western tragopan.

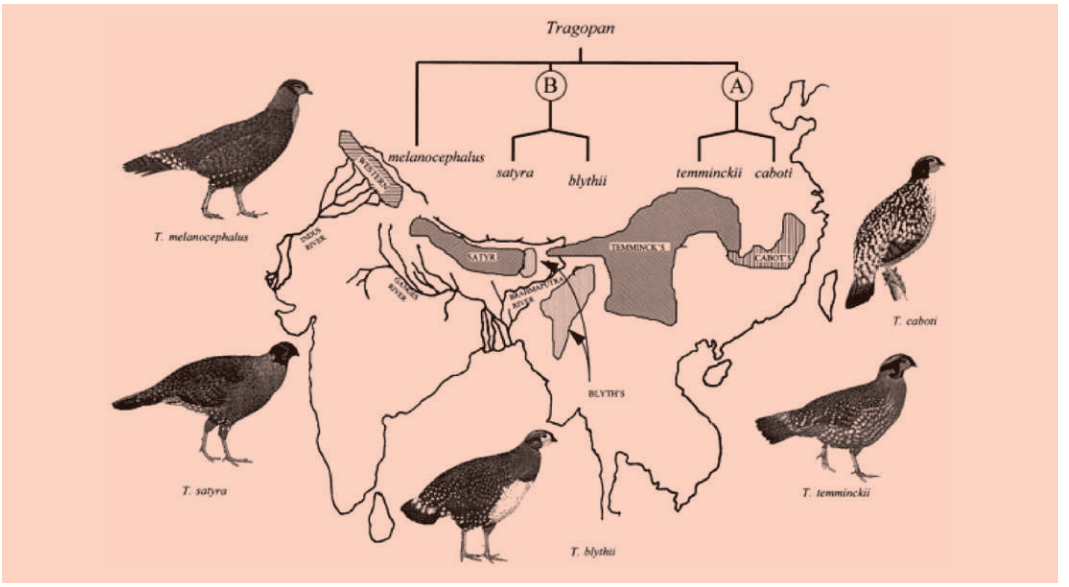

Figure 1 : Geographic Distributions (Johnsgard 1986) and Phylogenetic Relationship of Tragopan Species (Randi et al. 2000)

2.1. General Characteristics

Western tragopan is a medium sized pheasant and is sexually dimorphic; males being brightly coloured than their cryptically coloured female counterparts. The male birds are mostly greyish-black with prominent white dots on the back. They have conspicuous crimson patches on the upper breast, neck and face. Male birds possess lappets and fleshy horns to attract females during the breeding season. The vivid blue lappet in males has purplish marking running along the middle and pinkish markings along the margins. The lappet and the brightly coloured fleshy horns also become conspicuous during courtship display. The females are less distinctive in appearance. They have brownish- grey upperparts that are finely vermiculated with black spots. The red colour is totally absent in females except for the leg and face which are pinkish. The female birds also lack the colourful adornments of the males. Immature males resemble females though they have longer legs and have variable amount of crimson on neck and head.

Table 1 : Biological attributes of Western tragopan

Attributes	Males	Females
Body Length	65-75 cm	60-65 cm
Wing	~ 28 cm	~ 23.8 cm
Tail	~ 23.5 cm	~ 19.5 cm
Tarsus	~ 9.0 cm	~ 6.5 cm
Body Weight	1800-2200 g	1300-1400 g
Incubation Period	28 Days	
Clutch Size	2-4 eggs	

Source: Ramesh (2003)

2.2. Behaviour

Elusiveness of Western tragopan compounded with low density accounts for poor knowledge on the behaviour aspects of this species. Western tragopans are usually found in pairs or are solitary. Both the sexes are territorial, but the male birds are seen to defend their territory by vocalizing. They are primarily monogamous; the pair-forming is initiated at the beginning of their breeding season (April-May). The males display complex courtship behaviour to attract females at the commencement of breeding season. Rudimentary nests are built on the ground or on perches using sticks and grasses. The clutch size varies from 2-5 eggs; however, a nest with 6 eggs has also been recorded (Hume 1873–1875). Female incubate the eggs, while the male participates in tending to the chicks once the eggs are hatched.

Western tragopan is crepuscular, vocalizing and foraging during dawn or dusk. Their diet primarily consists of leaves of trees and shrubs, but also includes roots, flowers, acorns, seeds and berries. They also consume invertebrates like grubs and insects (Baker 1921–1930, Delacour 1977, Ali and Ripley 1968–1998, Roberts 1991–1992). These are wary birds, with a tendency to flush and fly a short distance when alarmed from nearby. However, when alarmed from a distance, the bird is reported to hide underneath rocks or in dense undergrowth, instead of flushing. The birds show reluctance to flush in winter as compared to other times of the year (Singh and Tu, 2007).

The advertisement calls recorded have phonetic renditions “waa waa waa”, “Khuwaah”, “whaa-eh whaa-eh” and alarm calls identified in the species are “quack” and “wuck wuck wuck”.

2.3. Habitat Ecology

Western tragopan is a habitat specialist and frequents conifer and oak communities with dense undergrowth of bamboo and other dense undergrowth (Ramesh, 2003). It generally uses the moist humus rich slopes for foraging. This species is reported to show altitudinal migration during winter, when heavy snow forced the birds to move down. The preferred summer habitat of this species is upper temperate forests between 2400m-3600m (asl). During winter, the bird is observed to descend to the elevation of 2000m-2800m (asl) and inhabit the broadleaf forests and grassy gullies.

2.4. Distribution

Western tragopan is confined to a narrow distribution limit in the northwest Himalaya, between the northern Pakistan, through Kashmir, Himachal Pradesh and the Garhwal part of Uttarakhand in India (Ramesh 2007). The species distribution formerly ranged from Swat catchment and Hazara in northern Pakistan through Kashmir and Himachal Pradesh to Garhwal in Uttarakhand. Currently the range has diminished considerably with only 2,000-3,000 sq. km area of potential habitat being available and the present population is distributed in five fragmented units. These populations are found in (1) Neelam Valley, (2) Kishtwar National Park and (3) Palas in Jammu and Kashmir, (4) Kulu (including Great Himalayan National Park) in Himachal Pradesh and (5) Bhilinguna in Garwhal, Uttarakhand (Gatson et al. 1983) (Figure 2).

2.5. Threats

Being a habitat specialist, the loss of habitat poses major threat for this species. This threat is compounded by the low breeding success from direct and indirect disturbances caused during collection of edible mushroom by the local people. Grazing of cattle, felling of trees and other anthropogenic disturbances also attribute to the declining population trend of this species. Hunting of this bird for their meat, and bright

plumage is another major threat for this endangered bird (Birdlife International, 2001).

2.6. Conservation status

Western tragopan is undoubtedly the rarest of the Himalayan pheasants, but due to its secretive nature and difficult habitat, no reliable population estimate is available. However, current estimates suggest that the wild population of Western tragopan is even lower than 5000 individuals (Gaston et al. 1983; Johnsgard 1986; Birdlife International 2001, Ramesh 2007). This population is also highly fragmented and reported to be declining which adds to the risk of extinction of this bird in wild. The species is thus listed as Vulnerable (VU) C2a (i) in IUCN Red Data List (2011) and Schedule I of the Indian Wildlife Protection Act, 1972. All the five extant species of Tragopan face potential risk of extinction from trade and thus, these are covered under Appendix I of CITES (July, 2006). A single captive population of 19 individuals exists at Sarahan Pheasantry, Himachal Pradesh and two birds are held captive in Kufri Zoological Park, Himachal Pradesh.

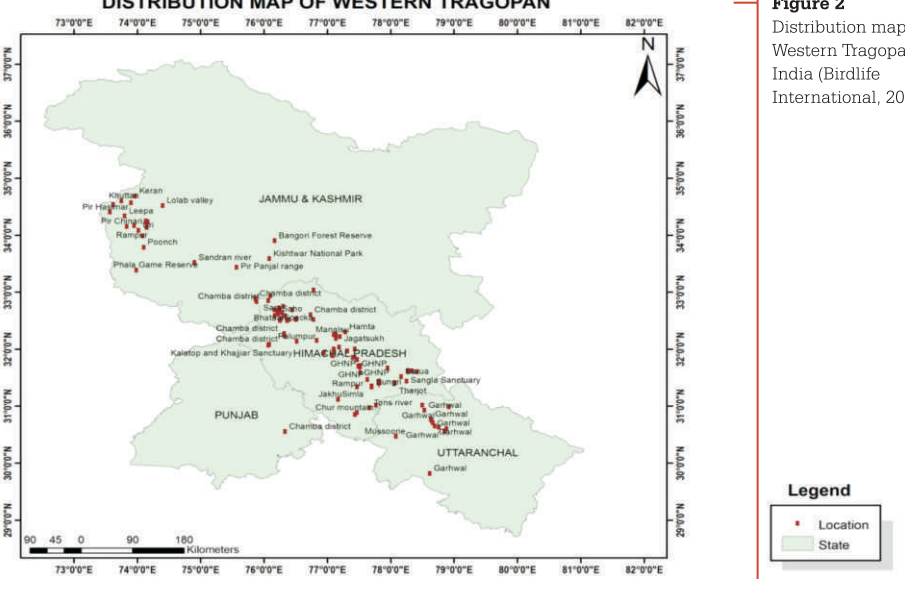

Figure 2
Distribution map of Western Tragopan in India (Birdlife International, 2001)

3

Methods

Data for preparation of this studbook was obtained from records of Sarahan Pheasantry, through WII's ongoing project on 'Reproductive biology and behaviour of captive and wild populations of Western tragopan in Himachal Pradesh'. Data was supported by primary information as on August 2011 by a research fellow of WII (Mr. Lakshminarasimha R.). Data in appropriate format was entered in SPARKS 1.5 software and studbook report was generated. Subsequently, the SPARKS dataset was imported in Poplink 1.3 and created ~.prn and ~.ped files for demographic and genetic analyses in pm2000. The software pm2000 was used to produce the census report, life tables, population projections, founder statistics, inbreeding coefficients, possible pairings and population planning. Additionally, descriptive accounts of population profile and breeding analyses have been presented.

4

Profile of Captive Population

As on August 2011, there are 21 living individuals of Western tragopan in captivity; 19 in Sarahan Pheasantry; 10 males and 09 females and two males in Kufri Zoological Park, transferred from Sarahan in 2009 (Table 2). In the historical context, a total of 37 individuals have been kept in the Pheasantry so far (1990 to mid 2011), however, pedigree details are available for 22 birds only (Table 3). Incidentally, none of the remaining birds (i.e. 15) contribute to the present population size; 13 birds are dead and two (both males) have been transferred to Kufri Zoological Park.

Table 2 : Listing of living Western tragopan in captivity in India

S. No.	House Name Identifiers Tag/Band	Studbook Number	Sex	Sire	Dam	Hatch Date	Location	Date	Event
1.	Abbu 2259Q	00001	M	Wild	Wild	~ 1999	Himachal Sarahan	~Jan 2001ñ1m ~Jan 2001ñ1m	Capture Transfer
2.	Raja 2256Q	00002	M	Wild	Wild	~ 2000	Himachal Sarahan	~Jan 2001ñ1m ~Jan 2002ñ1m	Capture Transfer
3.	Joney 2258Q	00003	M	Wild	Wild	~ 2001	Himachal Sarahan	~Feb2003ñ1m ~Feb2003ñ1m	Capture Transfer
4.	Neelu 2260Q	00004	F	Wild	Wild	~ 2001	Himachal Sarahan	~Feb2003ñ1m ~Feb2003ñ1m	Capture Transfer
5.	Rani 2256Q	00005	F	Wild	Wild	~ 2002	Himachal Sarahan	~Feb2004ñ1m ~Feb2004ñ1m	Capture Transfer
6.	Moti 2268Q	00006	M	Wild	Wild	~ 2003	Himachal Sarahan	~Apr 2005ñ1m ~Apr 2005ñ1m	Capture Transfer
7.	Rekha 2266Q	00007	F	Wild	Wild	~ 2003	Himachal Sarahan	~Feb2005ñ1m ~Feb2005ñ1m	Capture Transfer
8.	Ruchi 2267Q	00008	F	00001	00004	6 Jun 2005	Sarahan	6 Jun 2005	Hatch
9.	Shalu 2283Q	00009	F	Wild	Wild	~ 2005	Himachal Sarahan	~Apr 2008ñ1m ~Apr 2008ñ1m	Capture Transfer
10.	Sanju 2284Q	00010	M	Wild	Wild	~ 2006	Himachal Sarahan	~Apr 2008ñ1m ~Apr 2008ñ1m	Capture Transfer
11.	Shiv 2286Q	00013	M	00003	00008	24 Jun 2007	Sarahan	24 Jun 2007	Hatch
12.	Golu 2278Q	00014	M	00001	00004	27 Jun 2007	Sarahan	27 Jun 2007	Hatch
13.	Gudu 2281Q	00015	M	00002	00005	27 Jun 2007	Sarahan	27 Jun 2007	Hatch
14.	Sheela 2276Q	00017	F	00002	00005	27 Jun 2007	Sarahan	27 Jun 2007	Hatch
15.	Seema 2289Q	00018	F	00003	00008	12 Jun 2008	Sarahan	12 Jun 2008	Hatch
16.	Lata 2290Q	00020	F	00002	00005	26 Jun 2008	Sarahan	26 Jun 2008	Hatch
17.	Heena 2288Q	00022	F	00003	00008	30Jun 2008	Sarahan	30 Jun 2008	Hatch
18.	Teenu 2291Q	00023	M	00013	00017	14 Jun 2009	Sarahan	14 Jun 2009	Hatch
19.	Monu 2292Q	00024	M	00006	00016	14 Jul 2009	Sarahan	14 Jul 2009	Hatch
20.	Anu 2277Q	00025*	M	00001 /00002	00004 /00005	08 Jun 2007	Sarahan Kufri	08 Jun 2007 27 Apr 2009	Hatch Transfer
21.	Raju 2280Q	00026*	M	00001 /00002	00004 /00005	08 Jun 2007	Sarahan Kufri	08 Jun 2007 27 Apr 2009	Hatch Transfer

** Excluded from this Studbook analyses*

Table 3 : Historical Listing of Western Tragopan in Captivity in India

S. No.	House Name Identifiers Tag/Band	Studbook Number	Sex	Sire	Dam	Hatch Date	Location	Date	Event
1.	UnK1	-*	M	UnK	UnK	UnK	Daranghati May 1991	Jan 1990 Death	Capture
2.	UnK2	-*	F	UnK	UnK	UnK	Daranghati Oct 1992	Jan 1990 Death	Capture
3.	UnK3	-*	M	UnK	UnK	UnK	Thar Jot Feb 1995	Apr 1992 Death	Capture
4.	UnK4	-*	F	UnK	UnK	UnK	Thar Jot Mar 1994	Apr 1992 Death	Capture
5.	UnK5	-*	M	UnK	UnK	UnK	Daranghati Feb 1995	Jan 1993 Death	Capture
6.	UnK6	-*	F	UnK	UnK	UnK	Daranghati Aug 1997	Mar 1993 Death	Capture
7.	UnK7	-*	M	UnK	UnK	UnK	Daranghati Mar 1998	Jan 1996 Death	Capture
8.	UnK8	-*	F	UnK	UnK	UnK	Daranghati UK	Dec 1996 Death	Capture
9.	UnK9	-*	M	UnK	UnK	UnK	Kashapat Mar 1998	May 1997 Death	Capture
10.	UnK10	-*	F	UnK	UnK	UnK	Kashapat UK	Nov 1997 Death	Capture
11.	UnK11	-*	UnK	UnK	UnK	1993	Sarahan 1993	1993 Death	Hatch
12.	2257Q	-*	M	UnK	UnK	1993	Sarahan 2005	1993 Death	Hatch
13.	Abbu 2259Q	00001	M	Wild	Wild	~ 1999	Himachal Sarahan	~Jan 2001ñ1m ~Jan 2001ñ1m	Capture Transfer
14.	Raja 2256Q	00002	M	Wild	Wild	~ 2000	Himachal	~Jan 2001ñ1m ~Jan 2002ñ1m	Capture Transfer
15	Joney 2258Q	00003	M	Wild	Wild	~ 2001	Himachal Sarahan	~Feb2003ñ1m ~Feb2003ñ1m	Capture Transfer
16	Neelu 2260Q	00004	F	Wild	Wild	~ 2001	Himachal Sarahan	~Feb2003ñ1m ~Feb2003ñ1m	Capture Transfer
17.	Rani 2256Q	00005	F	Wild	Wild	~ 2002	Himachal Sarahan	~Feb2004ñ1m ~Feb2004ñ1m	Capture Transfer
18.	Moti 2268Q	00006	M	Wild	Wild	~ 2003	Himachal Sarahan	~Apr 2005ñ1m ~Apr 2005ñ1m	Capture Transfer
19.	Rekha 2266Q	00007	F	Wild	Wild	~ 2003	Himachal Sarahan	~Feb2005ñ1m ~Feb2005ñ1m	Capture Transfer
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21.	Shalu 2283Q	00009	F	Wild	Wild	~ 2005	Himachal Sarahan	~Apr 2008ñ1m ~Apr 2008ñ1m	Capture Transfer
22.	Sanju 2284Q	00010	M	Wild	Wild	~ 2006	Himachal Sarahan	~Apr 2008ñ1m ~Apr 2008ñ1m	Capture Transfer

S.. No.	House Name Identifiers Tag/Band	Studbook Number	Sex	Sire	Dam	Hatch Date	Location	Date	Event
23.	Papu 2285Q	00011	M	00002	00005	27 Apr 2007	Sarahan	27 Apr 2007 20 Apr 2010	Hatch Death
24.	Deepa 2282Q	00012	F	00001 /00002	00004 /00005	8 Jun 2007	Sarahan	8 Jun 2007 16 May 2010	Hatch Death
25.	Shiv 2286Q	00013	M	00003	00008	24 Jun 2007	Sarahan	24 Jun 2007	Hatch
26.	Golu 2278Q	00014	M	00001	00004	27 Jun 2007	Sarahan	27 Jun 2007	Hatch
27.	Gudu 2281Q	00015	M	00002	00005	27 Jun 2007	Sarahan	27 Jun 2007	Hatch
28.	Neetha 2279Q	00016	F	00002	00005	27 Jun 2007	Sarahan	27 Jun 2007 11 May 2010	Hatch Death
29.	Sheela 2276Q	00017	F	00002	00005	27 Jun 2007	Sarahan	27 Jun 2007	Hatch
30.	Seema 2289Q	00018	F	00003	00008	12 Jun 2008	Sarahan	12 Jun 2008	Hatch
31.	Lata 2290Q	00020	F	00002	00005	26 Jun 2008	Sarahan	26 Jun 2008	Hatch
32.	Neha 2287Q	00021	F	00003	00008	30 Jun 2008	Sarahan	30 Jun 2008 2 May 2010	Hatch Death
33.	Heena 2288Q	00022	F	00003	00008	30 Jun 2008	Sarahan	30 Jun 2008	Hatch
34.	Teenu 2291Q	00023	M	00013	00017	14 Jun 2009	Sarahan	14 Jun 2009	Hatch
35.	Monu 2292Q	00024	M	00006	00016	14 Jul 2009	Sarahan	14 Jul 2009	Hatch
36.	Anu 2277Q	00025*	M	00001 /00002	00004 /00005	08 Jun 2007	Sarahan Kufri	08 Jun 2007 27 Apr 2009	Hatch Transfer
37.	Raju 2280Q	00026*	M	00001 /00002	00004 /00005	08 Jun 2007	Sarahan Kufri	08 Jun 2007 27 Apr 2009	Hatch Transfer

** Excluded from this Studbook analyses*

5

Breeding Analyses

In 1993, Sarahan Pheasantry registered first ever breeding of Western tragopan anywhere in the world, with hatching of two out of three eggs. One of the chicks died after nine days and another one (a male) after 12 years in 2005. However, despite efforts, subsequent breeding success could not be achieved for over 10 years and was finally achieved in the year 2005, with hatching of one female (Ruchi 2267Q). The most productive year was 2007, when nine chicks were produced successfully; of these, six are still living. Thereafter, the breeding success declined substantially from four chicks in 2008 to two in 2009, and none in 2010, when there were high rate of adult mortality (n = 4; one male and three females), reportedly due to disease spread or nutrition deficiency in the population. In order to facilitate the birds to recover from infection so that adult mortality does not occur further, the breeding success was minimised by controlling the photoperiod in 2011, although delayed egg laying by more than one bird have been recorded.

Data available on breeding status during 2005-2010 indicate that most of the birds have laid eggs in the month of May (n= 36), followed by April (n = 24), June (23) and July (10), which roughly correspond to wild population. A total 261 eggs have been laid in these years (2005 to 2010), which is a significant productivity. However, there has been considerable proportion of mortality in the form of damage by the birds or dropping from perching, thin-shelled eggs, under-sized eggs and laid without any shells (Figure 4). It is noteworthy that over 120 normal eggs have been laid, but failures have been experienced in hatching and ensuring survival of hatched ones. Trend analysis reveals that only four pairs produced large number of normal eggs and thin-shelled eggs offset the overall breeding success in the Sarahan Pheasantry (Figure 5).

Three pairs of birds (Abbu-Neelu; Raja-Rani; Joney-Ruchi) have consistently produced large number of eggs during 2005-2010 (Figure 6 – 8), but the Raja-Rani pair produced substantial normal eggs and also raised chicks successfully in most occasions. Although Abbu-Neelu produced relatively large number of normal eggs, Joney-Ruchi raised chicks relatively high. Interestingly, six out of nine birds (66.7%) rescued from wild and four out of 14 birds (28.6%) born at Sarahan Pheasantry have bred. A closer analysis on the egg production and breeding success indicate that some pairs are able to adapt to condition and contribute substantially to conservation breeding program. However, the overall trend, indicating decreasing egg laying and high rate of mortality perhaps relate to the nutritional and psychological stress. It is a normal tendency for wild caught birds to lay eggs during the first breeding season in captivity due to hormonal triggers, and they are likely to lay more if the eggs are removed for hatching by broody hen or incubators. The trend is likely to continue if the environment is conducive. Or else, only the birds that have gained enough confidence contribute to the breeding success. For the conservation breeding program, these results have implication for ensuring adequate number of captive stock, and also to ensure that only effective founder is producing more, since these would maintain genetic diversity in the population. In any case, these are key requirements for wild population reinforcement and reintroduction purposes.

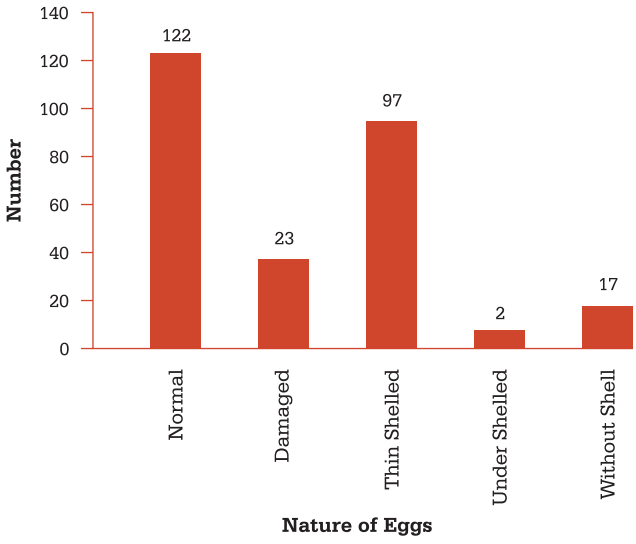


Figure 3
Nature of eggs produced during 2005-2010

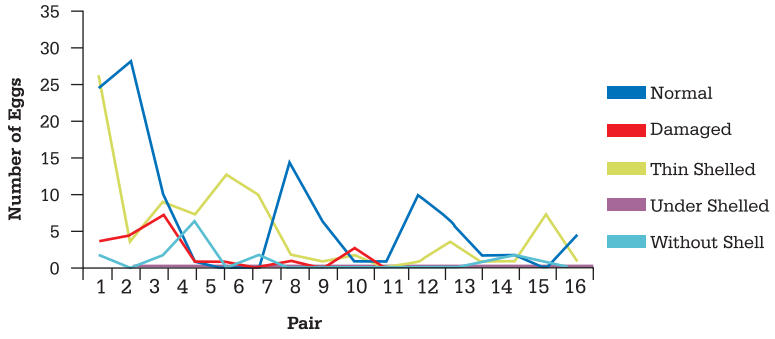


Figure 4
Trends of egg laying status from 16 pair combination pooled for 2005-2010

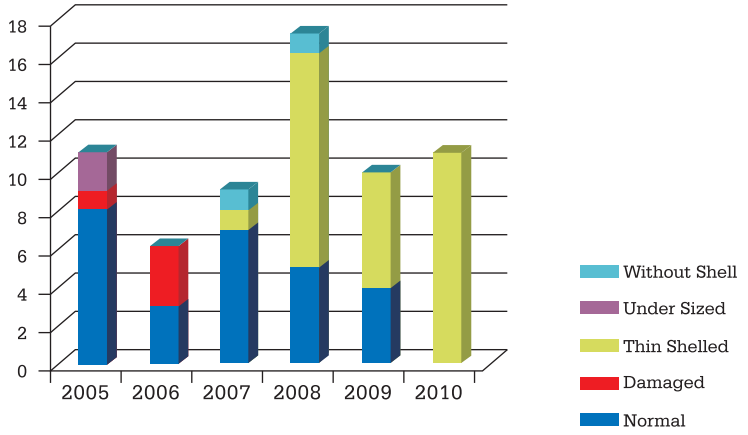


Figure 5
Status of egg produced by Abbu-Neelu pair during 2005-2010

Figure 6
Status of egg produced by Raja-Rani pair during 2005-2010

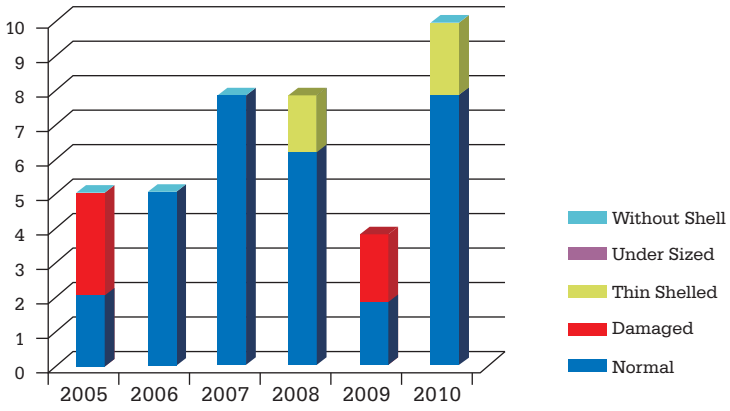
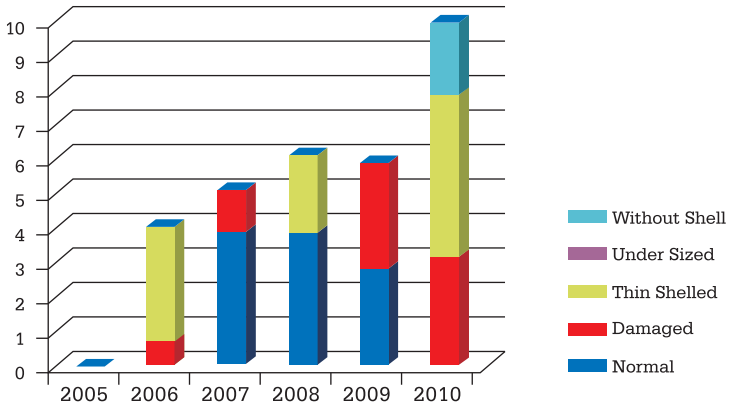


Figure 7
Status of egg produced by Joney - Ruchi pair during 2005-2010



6

Demographic Analyses

6.1. Census

The census graph (Figure 8) shows that although the population grew at a steady rate in the last ten years, there has been decline in the population size since 2009. The details of the census over the years are provided in Table 4.

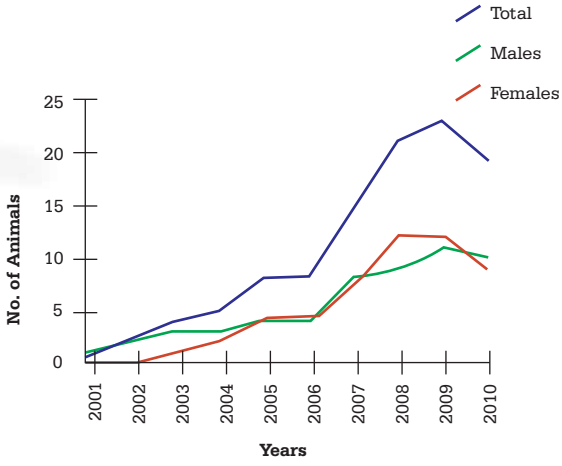


Figure 8
Census trends of Western tragopan in Sarahan Pheasantry

Table 4 : Census data of Western tragopan in Sarahan Pheasantry

Year	Total	Males	Females	Unsexed	Wild Born	Captive Born
2001	1	1	0	0	1	0
2002	2	2	0	0	2	0
2003	4	3	1	0	4	0
2005	8	4	4	0	7	1
2006	8	4	4	0	7	1
2007	15	8	7	0	7	8
2008	21	9	12	0	9	12
2009	23	11	12	0	9	10
2010	19	10	9	0	9	10

6.2. Age Distribution

Age distribution of Western tragopan in Sarahan Pheasantry indicates the proportion of population in each age class. Age pyramid (Figure 9) suggests that most individuals in the given population are in breeding age. However, absence of animals under certain age classes like juvenile and neonatal reflects a gap at the base of age pyramid which may be deleterious for the population. Also under certain age classes, the population is prominently skewed towards one of the sex. The details of age distribution have been provided in Table 5. Thus, there is a need to increase animals in the lower age classes and sex representation need to be balanced for all age classes.

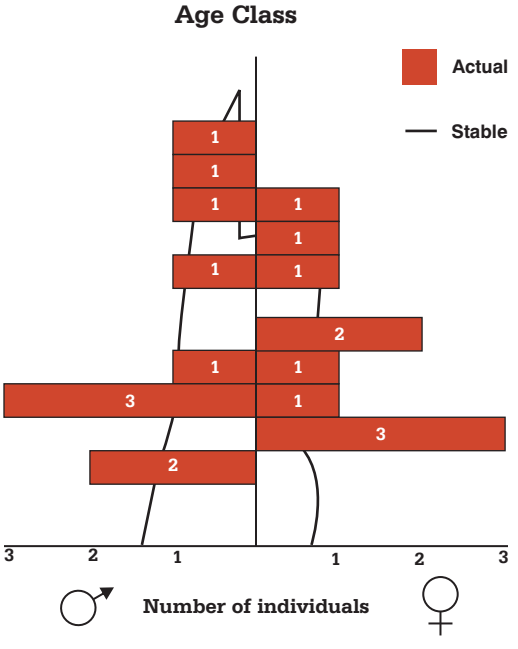


Figure 9
Age distribution of living Western tragopan population in Sarahan Pheasantry

Table 5 : Age Distribution of Living Western Tragopan Population

Age (x)	Male Actual	Male Stable	Female Actual	Female Stable
0	0	1.16	0	0.81
1	0	1.09	0	0.82
2	2	0.97	0	0.74
3	0	0.85	3	0.70
4	3	0.80	1	0.75
5	1	0.75	0	0.80
6	0	0.71	2	0.86
7	0	0.67	0	0.92
8	1	0.63	1	0.98
9	0	0.59	1	1.05
10	1	0.55	1	0.56
11	0	0.52	0	0.00
12	1	0.49	0	0.00
13	1	0.23	0	0.00
14	0	0.00	0	0.00

6.3. Life Table

Various characteristics of demography such as age distribution, age specific fertility and age specific mortality are summarized in the life table obtained for both the sexes (Table 6). Life table for Western tragopan reveals that the male population is growing at a rate of 0.06 with a generation length of 6.45 years, while female population is declining at a rate of -0.07 with a generation length of 4.2 years. Other demographic characteristics as obtained from life tables, like percent of population change per year (Lambda, □), rate of change per generation (Net Reproductive rate, R0) and average age at which the animal is producing offspring (Generation length, T) has been summarized in

Table 6 : Life Table for Male and Female Western Tragopan Population

Age	Males					Females				
	Qx	Px	Lx	Mx	Vx	Qx	Px	Lx	Mx	Vx
0	0.000	1.000	1.000	0.000	1.000	0.000	1.000	1.000	0.000	1.000
1	0.000	1.000	1.000	0.070	1.065	0.110	0.890	1.000	0.060	0.993
2	0.110	0.890	1.000	0.000	1.122	0.200	0.800	0.890	0.100	1.032
3	0.000	1.000	0.890	0.000	1.270	0.000	1.000	0.712	0.330	0.984
4	0.000	1.000	0.890	0.000	1.353	0.000	1.000	0.712	0.400	0.613
5	0.000	1.000	0.890	0.250	1.441	0.000	1.000	0.712	0.200	0.200
6	0.000	1.000	0.890	0.500	1.269	0.000	1.000	0.712	0.000	0.000
7	0.000	1.000	0.890	0.510	0.820	0.000	1.000	0.712	0.000	0.000
8	0.000	1.000	0.890	0.330	0.330	0.000	1.000	0.712	0.000	0.000
9	0.000	1.000	0.890	0.000	0.000	0.000	1.000	0.712	0.000	0.000
10	0.000	1.000	0.890	0.000	0.000	1.000	0.000	0.712	0.000	0.000
11	0.000	1.000	0.890	0.000	0.000	1.000	0.000	0.000	0.000	0.000
12	0.000	1.000	0.890	0.000	0.000	1.000	0.000	0.000	0.000	0.000
13	1.000	0.000	0.890	0.000	0.000	1.000	0.000	0.000	0.000	0.000
14	1.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000

Qx = mortality; **Px** = survival; **Lx** = cumulative survivorship; **Mx** = fecundity; **Vx** = expected future reproduction

Table 7 : Population Growth Rates

Population Parameters	Males	Females
Intrinsic rate of increase (r)	0.06	-0.07
Lambda	1.07	0.94
Net Reproductive rate (R0)	1.51	0.77
Generation length (T)	6.45	4.18

Age specific mortality rate (Qx) for female population is high for 0-2, 2-4, 8-10, 10-12 and 12-14 age classes (Figure 10), implying that the females are at a higher risk of death in these age classes, than the males. Age specific survivorship (Ix) is also higher for males across all the age classes (Figure 11). Age specific fertility rate or fecundity (Mx) is slightly skewed towards younger age classes for females that younger females reproduce more than males in the same age class, while older males reproduce more than females in the same age class (Figure 12). Reproductive value (Vx) is also higher for males; thus there are probabilities that male would live longer and produce more number of offspring than females in the population (Figure 13).

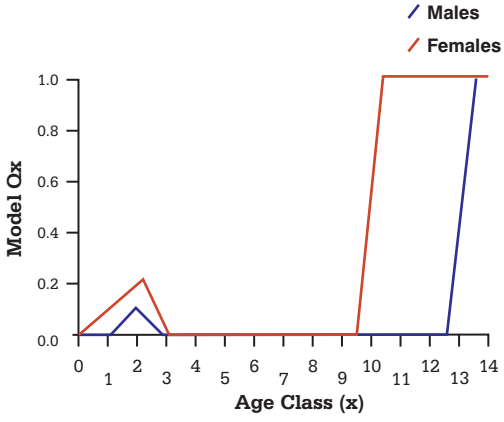


Figure 10 : Comparison of Male – Female Mortality

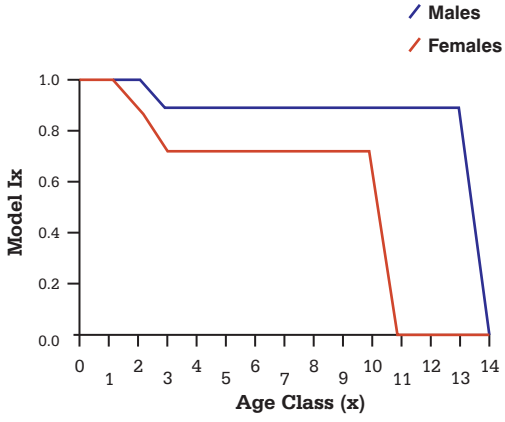


Figure 11 : Comparison of Age Specific Survivorship

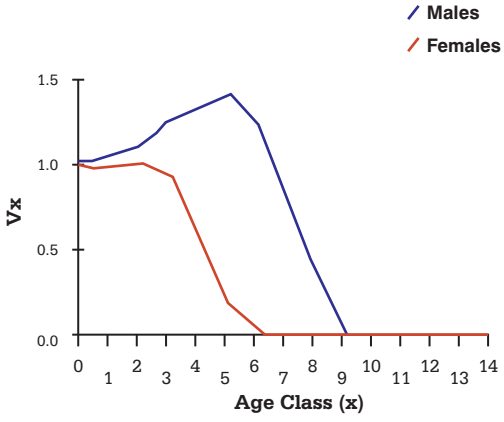


Figure 12 : Comparison of Male – Female Fecundity

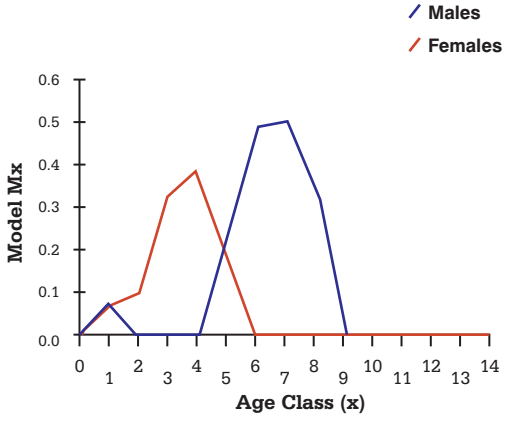
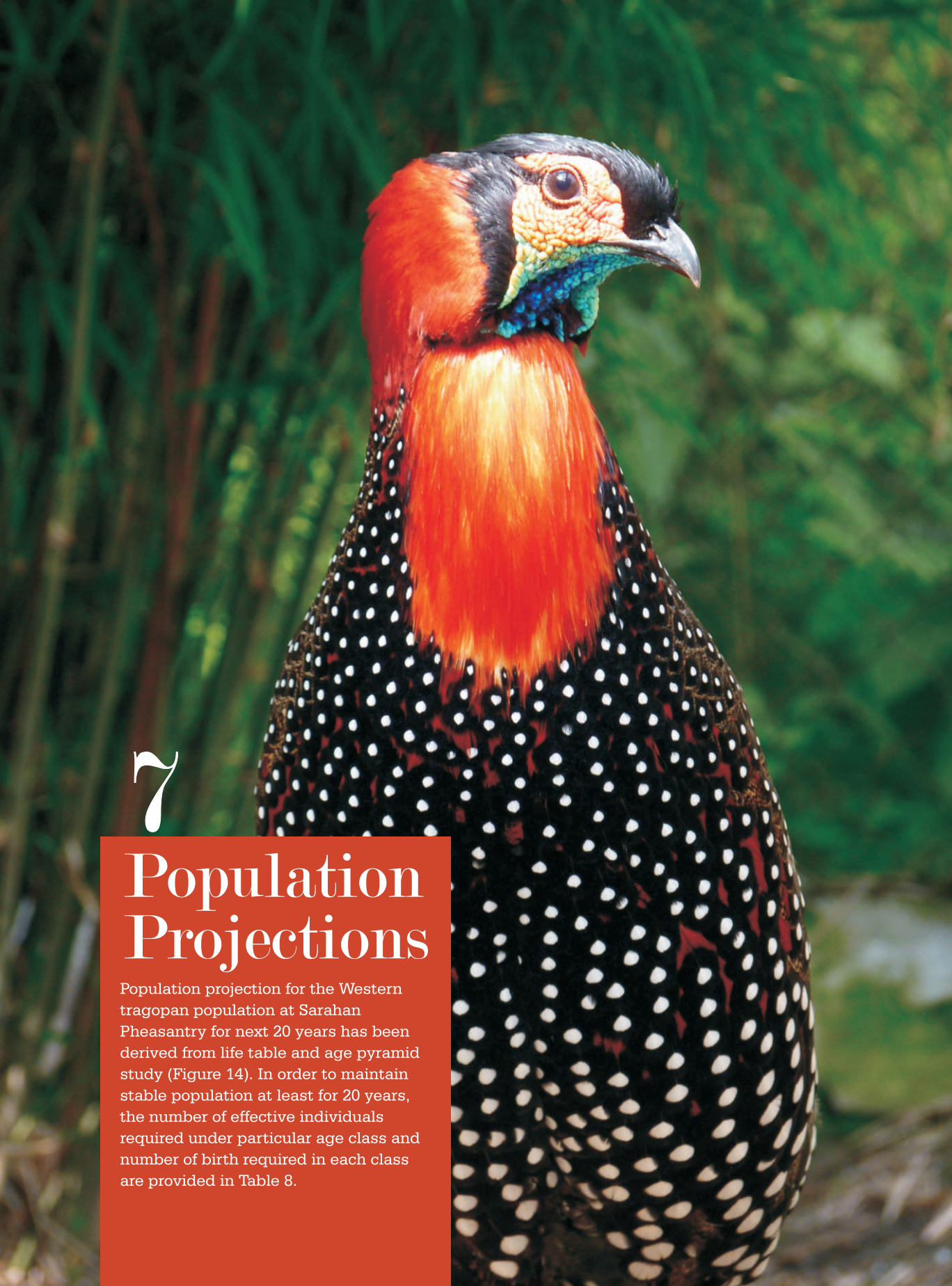


Figure 13 : Comparison of Male – Female Reproductive Value



7 Population Projections

Population projection for the Western tragopan population at Sarahan Pheasantry for next 20 years has been derived from life table and age pyramid study (Figure 14). In order to maintain stable population at least for 20 years, the number of effective individuals required under particular age class and number of birth required in each class are provided in Table 8.

Table 8 : Projected Age Class to Maintain A Stable Population for Next 20 Years

Age	Year										
Class	0	1	2	3	4	5	6	7	8	9	10
0	0.00	1.93	2.62	2.72	2.57	2.53	1.86	1.66	1.12	1.69	2.62
1	0.00	0.00	1.86	2.54	2.68	2.56	2.51	1.82	1.62	1.09	1.67
2	2.00	0.00	0.00	1.63	2.28	2.47	2.41	2.33	1.65	1.46	0.98
3	3.00	1.88	0.00	0.00	1.48	2.09	2.30	2.26	2.17	1.52	1.34
4	4.00	3.00	1.88	0.00	0.00	1.48	2.09	2.30	2.26	2.17	1.52
5	1.00	4.00	3.00	1.88	0.00	0.00	1.48	2.09	2.30	2.26	2.17
6	2.00	1.00	4.00	3.00	1.88	0.00	0.00	1.48	2.09	2.30	2.26
7	0.00	2.00	1.00	4.00	3.00	1.88	0.00	0.00	1.48	2.09	2.30
8	2.00	0.00	2.00	1.00	4.00	3.00	1.88	0.00	0.00	1.48	2.09
9	1.00	2.00	0.00	2.00	1.00	4.00	3.00	1.88	0.00	0.00	1.48
10	2.00	0.00	1.50	0.00	1.00	1.00	3.50	1.50	1.88	0.00	0.00
11	0.00	1.00	0.00	1.00	0.00	0.00	1.00	3.00	0.00	1.88	0.00
12	1.00	0.00	1.00	0.00	1.00	0.00	0.00	1.00	3.00	0.00	1.88
13	1.00	0.50	0.00	0.50	0.00	0.50	0.00	0.00	0.50	1.50	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**19.0**	**17.9**	**18.9**	**20.3**	**20.9**	**21.5**	**22.0**	**21.3**	**20.1**	**19.4**	**20.3**

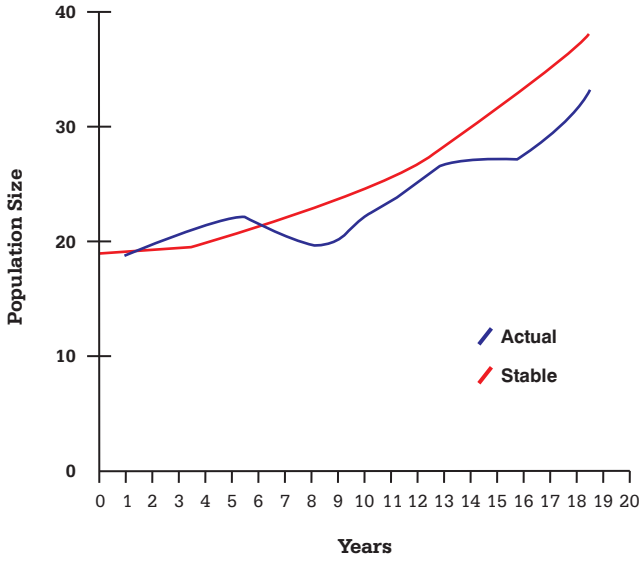


Figure 14
Population Projection
for Next 20 Years

8

Genetic Analyses

Results of genetic analysis show that 86% genetic diversity is being retained by the Western tragopan population at Sarahan Pheasantry. The gene value (which is an expression of expected heterozygosity if the given population is bred randomly) was calculated to be 0.86, which is relatively moderate. Although current population size is 19, mean 'effective' population size (Ne; i.e. individuals offering genetic viability to next generation) is only 10.63 over the past 1.3 generations. The current Ne is even lesser at 8.89. Therefore, it is critical to understand the status effective population size, and that efficient management intervention would involve increasing the effective population size, than merely increasing the size of the small population. This can possibly be achieved by equalizing the sex ratio, decreasing the variability in family size, checking the fluctuations in the population size over generations and avoiding overlap of generations. Based on the information available on Sarahan Pheasantry, the population genetics have been summarized in Table 9.

Table 9 : Genetic Status of The Captive Western Tragopan Population			
Genetic variables	**Current**	**Potential**	
Founders	6	3+	
Founder genome equivalents	3.57	9	
Founder genome surviving	4.68	9	
Gene diversity retained	0.86	0.94	
Population mean kinship	0.14	0.06	
Mean inbreeding	0	0.06	
Ne / N	0.47	-	
% of pedigree known	100	-	

8.1. Founder Statistics

The founder statistics show that there are six founders with living descendants in the population. However, the Founder Genome Equivalents (fge), which represents the amount of genetic variation contributed (alleles retained) by the founders, equals to genetic variation contributed by 3.6 founders if their allelic retention is 1. The sum total of allelic retentions of individual founders expressed as Founder Genomes Surviving was calculated to be 4.7. The values of' Founder Genome Equivalents' and 'Founder Genome Surviving' are low because studbook numbers 00001 (Abbu) and 00004 (Neelu) are over-represented, while studbook number 00006 (Moti) is under-represented. Studbook numbers 00007 (Rekha), 00009 (Shalu) and 00010 (Sanju) have not been represented at all (Table 10). Thus, there is a need to equalize the founder representation so the under-represented founder should be given more breeding opportunities. It should be noted that increasing breeding of under-represented founder's descendants may increase loss of heterozygosity. The founder statistics on key parameters such as founder representation, founder contribution, founder allele retention and potential founder allele retention have been provided in Table 10 and Figures 15, 16, 17 and 18.

Table 10 : Founder Statistics							
Studbook #	**Sex**	**Age**	**Representation**	**Contribution**	**Allele Retention**	**Potential Retention**	**Descendants**
00001	M	13	0.1875	1.8750	0.7475	1.0000	6.00
00002	M	12	0.2000	2.0000	0.9050	1.0000	5.00
00003	M	10	0.1750	1.7500	0.8765	1.0000	4.00
00004	F	10	0.1875	1.8750	0.7490	1.0000	6.00
00005	F	9	0.2000	2.0000	0.9040	1.0000	5.00
00006	M	8	0.0500	0.5000	0.5000	1.0000	1.00
00007	F	8	0.0000	0.0000	0.0000	1.0000	0.00
00009	F	6	0.0000	0.0000	0.0000	1.0000	0.00
00010	M	5	0.0000	0.0000	0.0000	1.0000	0.00

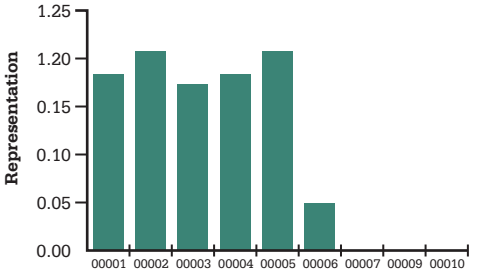


Figure 15 Founder Representation **Studbook#**

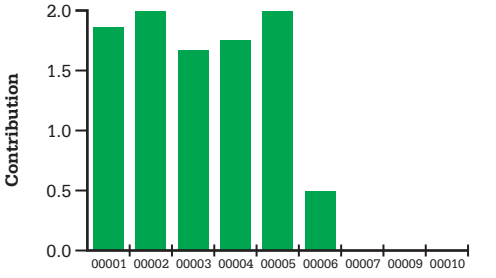


Figure 16 Founder contributions **Studbook#**

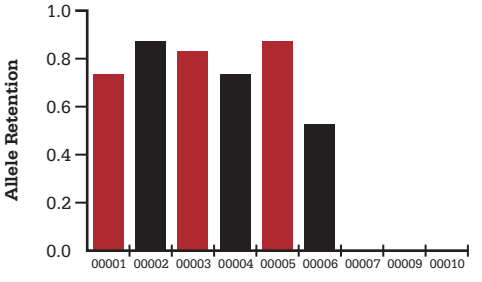


Figure 17 Founder Allele Retention **Studbook#**

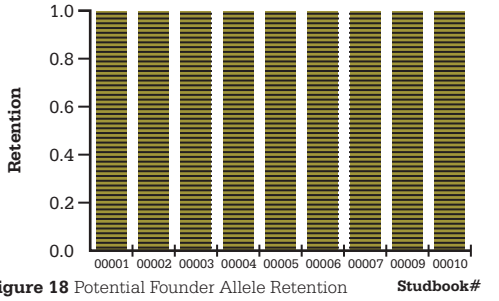


Figure 18 Potential Founder Allele Retention **Studbook#**

8.2. Individual Statistics

Individual statistics table summarizes the genetic data for individual captive Western tragopan housed in Sarahan Pheasantry. It is pertinent to note that none of the birds in Sarahan Pheasantry are inbred. However, the birds with low mean kinship (Mk) and less number of offspring should be preferably bred.

Table 11 : Individual Statistics

Studbook #	Sex	Sire	Dam	Age	Known	F	Mk	Kv	Foke	Progeny	Additional Ids
00001	M	Wild	Wild	13	100	0	0.09	0.08	3.8	2	Abbu 2259q
00002	M	Wild	Wild	12	100	0	0.10	0.10	4.0	5	Raja 2256q
00003	M	Wild	Wild	10	100	0	0.09	0.10	3.5	4	Joney 2258q
00004	F	Wild	Wild	10	100	0	0.09	0.08	3.8	2	Neelu 2260q
00005	F	Wild	Wild	9	100	0	0.10	0.10	4.0	5	Rani 2256q
00006	M	Wild	Wild	8	100	0	0.03	0.03	1.0	1	Moti 2268q
00007	F	Wild	Wild	8	100	0	0.00	0.00	0.0	0	Rekha 2266q
00008	F	00001	00004	6	100	0	0.16	0.13	6.5	4	Ruchi 2267q
00009	F	Wild	Wild	6	100	0	0.00	0.0	0.0	0	Shalu 2283q
00010	M	Wild	Wild	5	100	0	0.00	0.0	0.0	0	Sanju 2284q
00013	M	00003	00008	4	100	0	0.16	0.16	6.5	1	Shiv 2286q
00014	M	00001	00004	4	100	0	0.12	0.12	4.8	0	Golu 2278q
00015	M	00002	00005	4	100	0	0.13	0.14	5.0	0	Gudu 2281q
00017	F	00002	00005	4	100	0	0.14	0.13	5.5	1	Sheela 2276q
00018	F	00003	00008	3	100	0	0.15	0.14	6.0	0	Seema 2289q
00019	F	00002	00005	3	100	0	0.13	0.13	5.0	0	Lata 2290q
00021	F	00003	00008	3	100	0	0.15	0.14	6.0	0	Heena 2288q
00022	M	00013	00017	2	100	0	0.18	0.18	7.0	0	Teenu 2291q
00023	M	00006	00016	2	100	0	0.09	0.10	3.8	0	Monu 2292q

9

Population Planning and Breeding Recommendations

Association of Zoos and Aquarium's (AZA) Species Survival Plan (SSP) recommends certain population genetic management goal, i.e. 90% genetic diversity for 100 years. Population modelling of captive Western tragopan in Sarahan Pheasantry in pm2000 software, suggests that for achieving the population genetic management, a very large number of birds would be required. Such target is difficult to achieve in the present situation, since Sarahan Pheasantry is the lone holding institution for Western tragopan, [two individuals housed in Kufri Zoological Park were transferred from Sarahan]. Hence, a feasible genetic management goal of maintaining 90% genetic diversity for 50 years is suggested; for which a population of 52 individuals needs to be maintained with the addition of one founder per year for the next 50 years (Table 12).

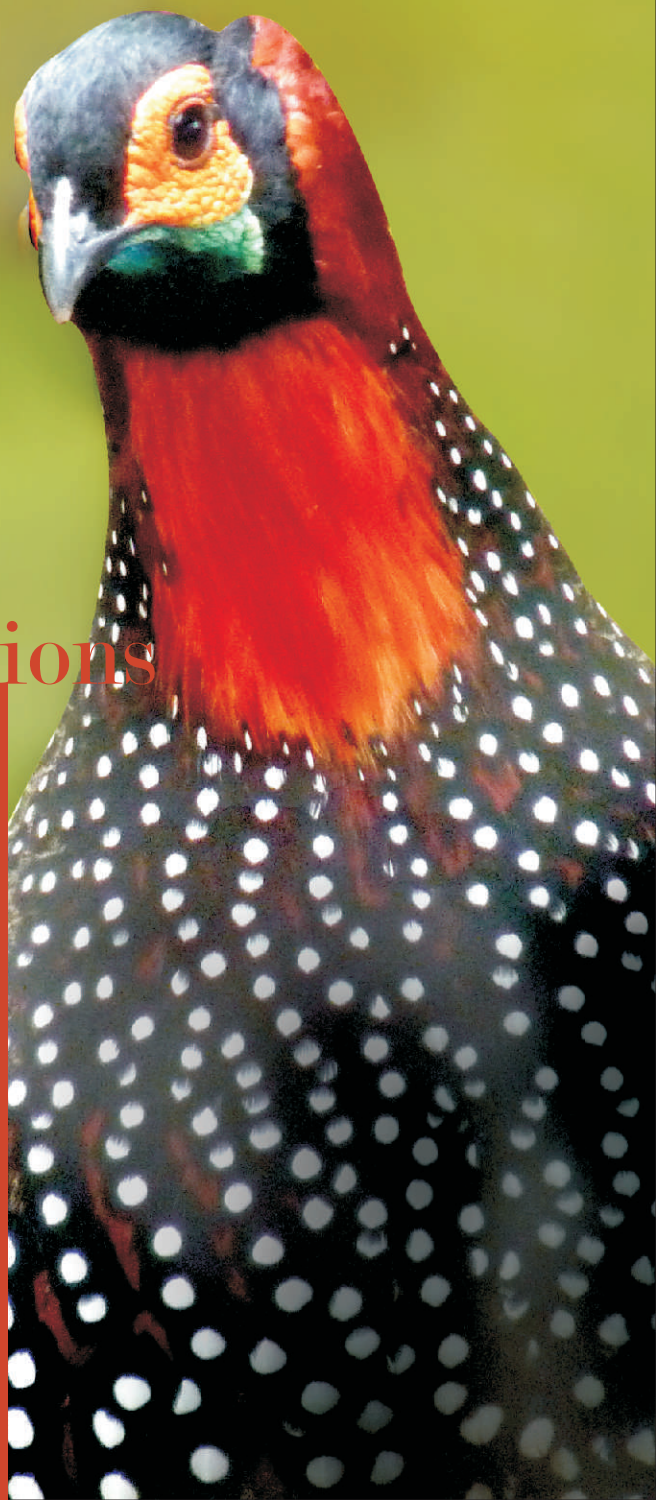


Table 12 : Management Strategy

Population Variables	Planned
Generation Length	5.30
Maximum Potential Population Growth Rate	1.00
Current Population Size	8.70
Current Effective Size	8.70
Ratio of Ne/N	0.46
Current Gene Diversity	0.86
Maximum Allowable Population Size	52.00
New Founders per Addition Event	01.00

Mean kinship (MK) is the most important genetic parameter for making decision on which animal in the population should be given priority in breeding (Table 13). It is a measure of relatedness of an individual with other living animals (descendants & captive bred), with '0' indicating no relatedness to any individual in the population and '1' indicating relatedness to all the individuals. Therefore, the probable pairing options in Sarahan Pheasantry for breeding were selected on the basis of least mean kinship values (Table 14). However, pairing option should also consider past histories of the pairs, such that new pair combination (if required) is compatible and that it does endanger founder population.

Table 13 : Ordered Mean Kinships

Rank	Males				Females			
	Studbook#	MK	Known	Age	Studbook#	MK	Known	Age
1	00010	0.00	100	5	00007	0.00	100	8
2	00006	0.03	100	8	00009	0.00	100	6
3	00003	0.09	100	10	00004	0.09	100	10
4	00001	0.09	100	13	00005	0.10	100	9
5	00023	0.09	100	2	00019	0.13	100	3
6	00002	0.10	100	12	00017	0.14	100	4
7	00014	0.12	100	4	00018	0.15	100	3
8	00015	0.13	100	4	00021	0.15	100	3
9	00013	0.16	100	4	00008	0.16	100	6
10	00022	0.18	100	2	-	-	-	-

Table 14 : Pairing Option for Western Tragopan Population in Sarahan Pheasantry

S. No.	Studbook #	Age	Suggested Pair
1.	00001 (Abbu)	~12	00004 (Neelu), 00005 (Rani) , 00007 (Rekha), 00009 (Shalu), 00017 (Sheela), 00019 (Lata)
2.	00002 (Raja)	~11	00004 (Neelu), 00005 (Rani), 00007 (Rekha), 00008 (Ruchi), 00009 (Shalu), 00018 (Seema), 00021 (Heena)
3.	00003 (Joney)	~10	00004 (Neelu), 00005 (Rani), 00007 (Rekha) , 00008 (Ruchi), 00009 (Shalu), 00017 (Sheela), 00019 (Lata)
4.	00004 (Neelu)	~10	00001 (Abbu), 00002 (Raja), 00003 (Joney), 00006 (Moti), 00010 (Sanju), 00015 (Gudu), 00023 (Monu)
5.	00005 (Rani)	~9	00001 (Abbu), 00002 (Raja), 00003 (Joney), 00006 (Moti), 00010 (Sanju), 00013 (Shiv), 00014 (Golu)
6.	00006 (Moti)	~8	00004 (Neelu), 00005 (Rani), 00007 (Rekha), 00008 (Ruchi), 00009 (Shalu), 00017 (Sheela),00018 (Seema), 00019 (Lata), 00021 (Heena)
7.	00007 (Rekha)	~8	00001 (Abbu), 00002 (Raja), 00003 (Joney), 00006 (Moti), 00010 (Sanju), 00013 (Shiv), 00014 (Golu), 00015 (Gudu), 00022 (Teenu), 00023 (Monu)
8.	00008 (Ruchi)	6	00002 (Raja), 00003 (Joney), 00006 (Moti), 00010 (Sanju), 00015 (Gudu), 00023 (Monu) 9.00009 (Shalu)~600001(Abbu), 00002 (Raja), 00003 (Joney), 00006 (Moti), 00010 (Sanju), 00013 (Shiv), 00014 (Golu), 00015 (Gudu), 00022 (Teenu), 00023 (Monu)
10.	00010 (Sanju)	~5	00004 (Neelu), 00005 (Rani), 00007 (Rekha), 00008 (Ruchi), 00009 (Shalu), 00017 (Sheela), 00018 (Seema), 00019 (Lata), 00021 (Heena)
11.	00013 (Shiv)	4	00005 (Rani), 00007 (Rekha), 00009 (Shalu), 00017 (Sheela), 00019 (Lata)
12.	00014 (Golu)	4	00005 (Rani), 00007 (Rekha), 00009 (Shalu), 00017 (Sheela), 00019 (Lata)
13.	00015 (Gudu)	4	00004 (Neelu), 00007 (Rekha), 00008 (Ruchi), 00009 (Shalu), 00018 (Seema), 00021 (Heena)
14.	00017 (Sheela)	4	00001(Abbu), 00003 (Joney), 00006 (Moti), 00010 (Sanju), 00013 (Shiv), 00014 (Golu)
15.	00018 (Seema)	3	00002 (Raja), 00006 (Moti), 00010 (Sanju), 00015 (Gudu), 00023 (Monu)
16.	00019 (Lata)	3	00001 (Abbu), 00003 (Joney), 00006 (Moti), 00010 (Sanju), 00013 (Shiv), 00014 (Golu)
17.	00021 (Heena)	3	00002 (Raja), 00006 (Moti), 00010 (Sanju), 00015 (Gudu), 00023 (Monu)
18.	00022 (Teenu)	2	00007 (Rekha), 00009 (Shalu)
19.	00023 (Monu)	2	00004 (Neelu), 00007 (Rekha), 00008 (Ruchi), 00009 (Shalu), 00018 (Seema), 00021 (Heena)

10 General Remarks

The analyses presented in this Studbook are constrained by low population size and specifically, the demographic analyses using software SPARKS and pm2000 should be viewed with caution. However, once the population size is achieved over <30 individuals, the analysis can be repeated and desired accuracy can be achieved.

- The genetic analysis was performed with an assumption that the founder individuals were drawn from un-related populations (both wild and captive). Given the absence of detailed location information and DNA analysis, such an assumption needs to be validated. For instance, as per the records, the five birds [Studbook# 00001 (Abbu), 00006 (Moti), 00004 (Neelu), 00007 (Rekha) and 00005 (Rani)] were rescued from Daranghati WLS, with all but Rekha and Moti were rescued in different time scale. It is, therefore, difficult to place whether or not these are from same population within Daranghati.
- The key information emerging from the Studbook relates to pairing options, provided on the basis of mean kinship and inbreeding coefficient. Since the entire pedigree for the Western tragopan population is known, these mating recommendations are reliable and it is further helpful to consider breeding history of specific pairs. This information will be of significant help to manage the small population by avoiding inbreeding and retaining maximum gene diversity in the population, which the population is capable of retaining.
- It is pertinent to reiterate that the Western tragopan population in Sarahan Pheasantry is under active Conservation Breeding program, and it is helpful to breed all the founders extensively, preferably with other founders. However, after establishing actual inbreeding coefficient in the captive population based on DNA, the maximum capacity or the stable population size should be decided on the basis of Population Viability Analysis (PVA).
- Presently, it is of utmost importance to control fluctuations in the population size and to optimize the sex ratio. It is also important to ascertain founder kinship, as the genetic diversity (heterozygosity and allelic diversity) retained in the population is a function of relationship to the base population (i.e. founder individuals).
- It is prudent to mention that Studbook alone does not capture the actual heterozygosity and thus, the effective population size. These uncertainties and gaps could be effectively addressed by DNA profiling of these birds, which has been envisaged in the ongoing project.

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Appendix 1 : Glossary of Terms

Demographic Terms

Age Distribution : A two-way classification showing the numbers or percentages of individuals in various age and sex classes.

Ex, Life Expectancy : Average years of further life for an animal in age class x.

Lambda, □ (Population Growth Rate) : The proportional change in population size from one year to the next. Lambda can be based on life-table calculations (the expected lambda) or from observed changes in population size from year to year. A lambda of 1.11 means a 11% per year increase; lambda of .97 means a 3% decline in size per year.

lx, Age-Specific Survivorship : The probability that a new individual (e.g., age 0) is alive at the beginning of age x. Alternatively, the proportion of individuals which survive from birth to the beginning of a specific age class.

Mx, Fecundity : The average number of same-sexed young born to animals in that age class. Because SPARKS is typically using relatively small sample sizes, SPARKS calculates Mx as 1/2 the average number of young born to animals in that age class. This provides a somewhat less "noisy" estimate of Mx, though it does not allow for unusual sex ratios. The fecundity rates provide information on the age of first, last, and maximum reproduction.

Px, Age-Specific Survival : The probability that an individual of age x survives one time period; is conditional on an individual being alive at the beginning of the time period. Alternatively, the proportion of individuals which survive from the beginning of one age class to the next.

Qx, Mortality : Probability that an individual of age x dies during time period. Qx = 1-Px The proportion of individuals that die during an age class. It is calculated from the number of animals that die during an age class divided by the number of animals that were alive at the beginning of the age class (i.e.-"at risk").

Risk (Qx or Mx) : The number of individuals that have lived during an age class. The number at risk is used to calculate Mx and Qx by dividing the number of births and deaths that occurred during an age class by the number of animals at risk of dying and reproducing during that age class.

Vx, Reproductive Value : The expected number of offspring produced this year and in future years by an animal of age x.

Genetic Terms

Allele Retention : The probability that a gene present in a founder individual exists in the living, descendant population.

Current Gene Diversity (GD) : The proportional gene diversity (as a proportion of the sourcepopulation) is the probability that two alleles from the same locus sampled at random from the population will be identical by descent. Gene diversity is calculated from allele frequencies, and is the heterozygosity expected in progeny produced by random mating, and if the population were in Hardy-Weinberg equilibrium.

Effective Population Size (Inbreeding Ne) : The size of a randomly mating population of constant size with equal sex ratio and a Poisson distribution of family sizes that would (a) result in the same mean rate of inbreeding as that observed in the population, or (b) would result in the same rate of random change in gene frequencies (genetic drift) as observed in the population. These two definitions are identical only if the population is demographically stable (because the rate of inbreeding depends on the distribution of alleles in the parental generation, whereas the rate of gene frequency drift is measured in the current generation).

FOKE, First Order Kin Equivalents : The number of first-order kin (siblings or offspring) that would contain the number of copies of an individuals alleles (identical

by descent) as are present in the captive-born population. Thus an offspring or sib contributes 1 to FOKE; each grand-offspring contributes 1/2 to FOKE; each cousin contributes 1/4 to FOKE. FOKE = 4*N*MK, in which N is the number of living animals in the captive population.

Founder : An individual obtained from a source population (often the wild) that has no known relationship to any individuals in the derived population (except for its own descendants).

Founder Contribution : Number of copies of a founder's genome that are present in the living descendants. Each offspring contributes 0.5 whereas each grand-offspring contributes 0.25, etc.

Founder Genome Equivalents (FGE) : The number wild-caught individuals (founders) that would produce the same amount of gene diversity as does the population under study. The gene diversity of a population is 1 - 1 / (2 * FGE).

Founder Genome Surviving : The sum of allelic retentions of the individual founders (i.e., the product of the mean allelic retention and the number of founders).

Founder Representation : Proportion of the genes in the descendant population that derives from that founder. I.e., proportional Founder Contribution.

GU, Genome Uniqueness : Probability that an allele sampled at random from an individual is not present, identical by descent, in any other living individual in the population. GU-all is the genome uniqueness relative to the entire population. GU-Desc is the genome uniqueness relative to the living non-founder, descendants.

Inbreeding Coefficient (F) : Probability that the two alleles at a genetic locus are identical by descent from an ancestor common to both parents. The mean inbreeding coefficient of a population will be the proportional decrease in observed heterozygosity relative to the expected heterozygosity of the founder population.

KV, Kinship Value : The weighted mean kinship of an animal, with the weights being the reproductive values of each of the kin. The mean kinship value of a population predicts the loss of gene diversity expected in the subsequent generation if all animals were to mate randomly and all were to produce the numbers of offspring expected for animals of their age.

Mean Generation Time (T) : The average time elapsing from reproduction in one generation to the time the next generation reproduces. Also, the average age at which a female (or male) produces offspring. It is not the age of first reproduction. Males and females often have different generation times.

Mean Kinship (MK) : The mean kinship coefficient between an animal and all animals (including itself) in the living, captive-born population. The mean kinship of a population is equal to the proportional loss of gene diversity of the descendant (captive-born) population relative to the founders and is also the mean inbreeding coefficient of progeny produced by random mating. Mean kinship is also the reciprocal of two times the founder genome equivalents: MK = 1 / (2 * FGE). MK = 1 - GD.

Percent Known : Percent of an animal's genome that is traceable to known Founders. Thus, if an animal has an UNK sire, the % Known = 50. If it has an UNK grandparent, % Known = 75.

Prob Lost : Probability that a random allele from the individual will be lost from the population in the next generation, because neither this individual nor any of its relatives pass on the allele to an offspring. Assumes that each individual will produce a number of future offspring equal to its reproductive value, Vx.

Appendix 2 : Pedigree Charts

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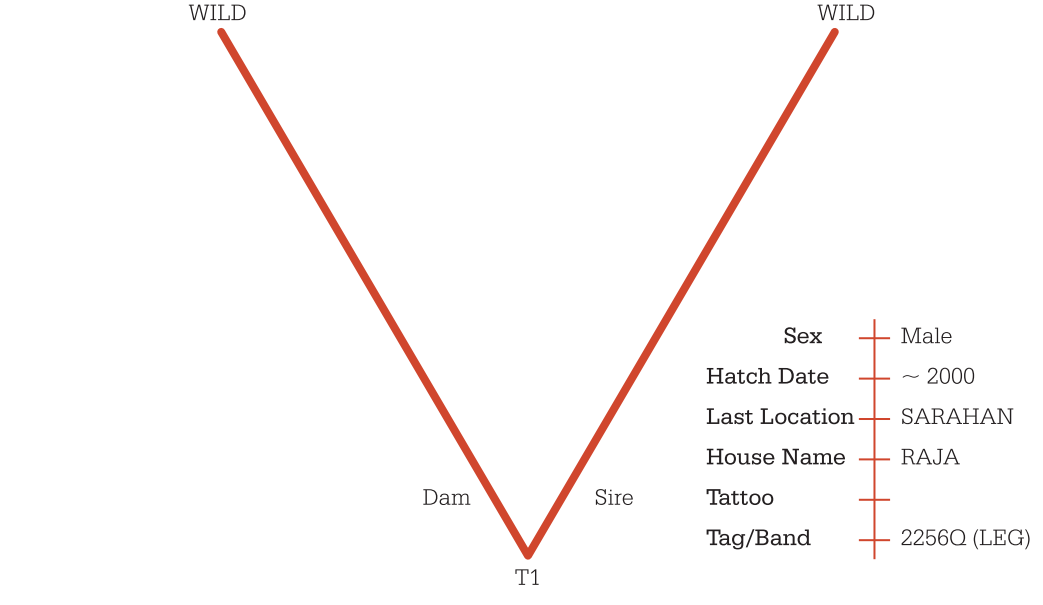

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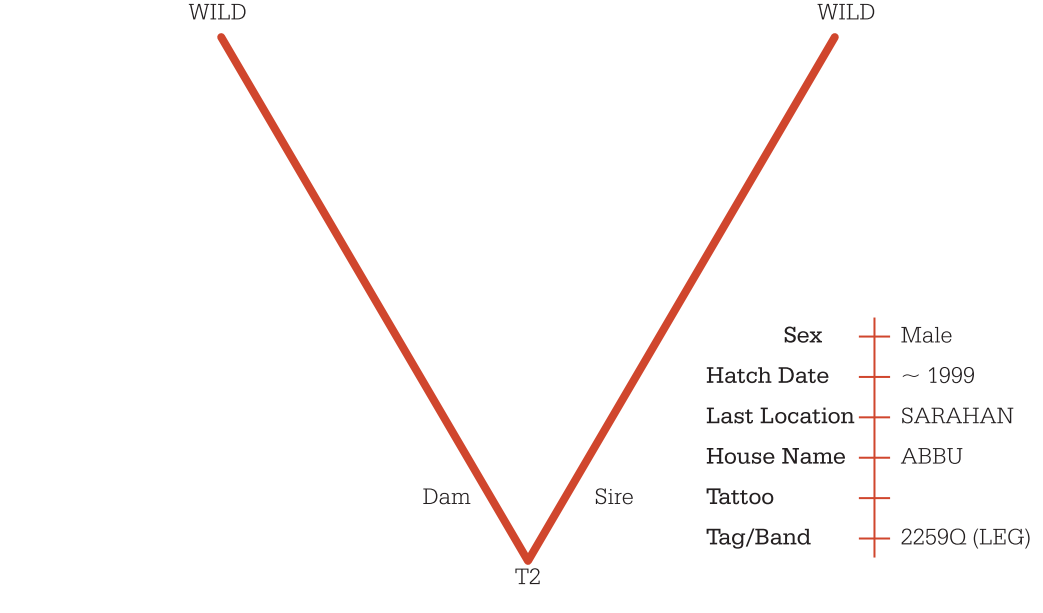

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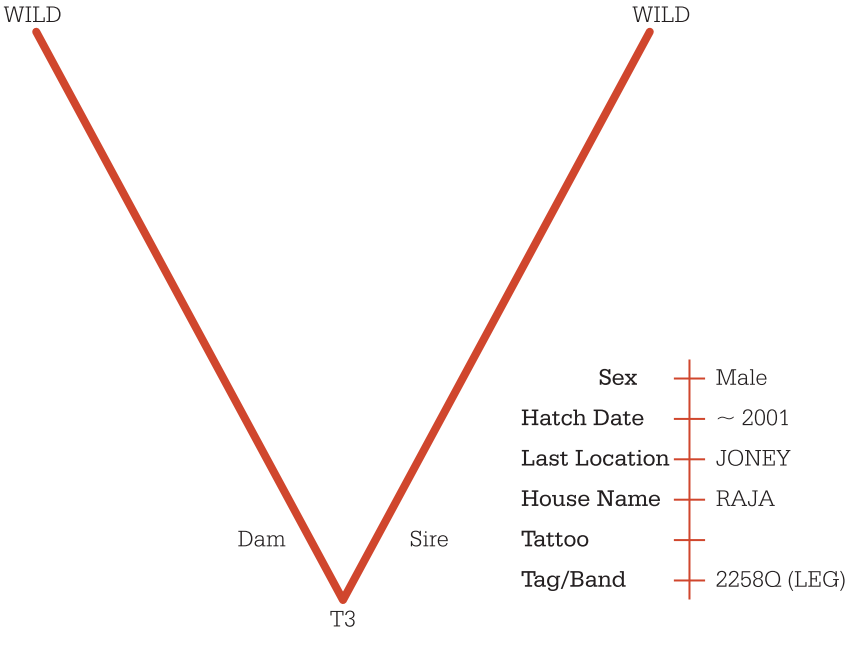

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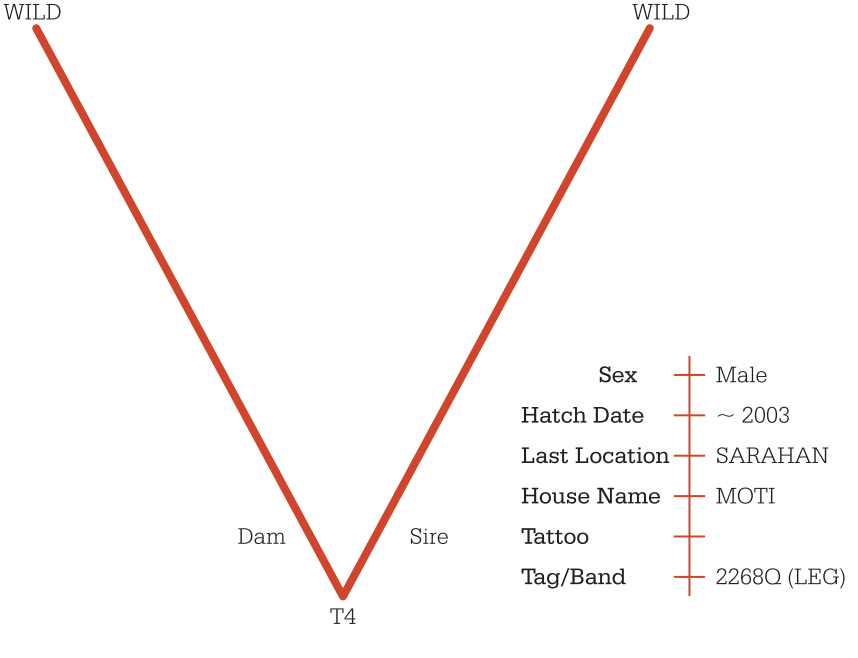

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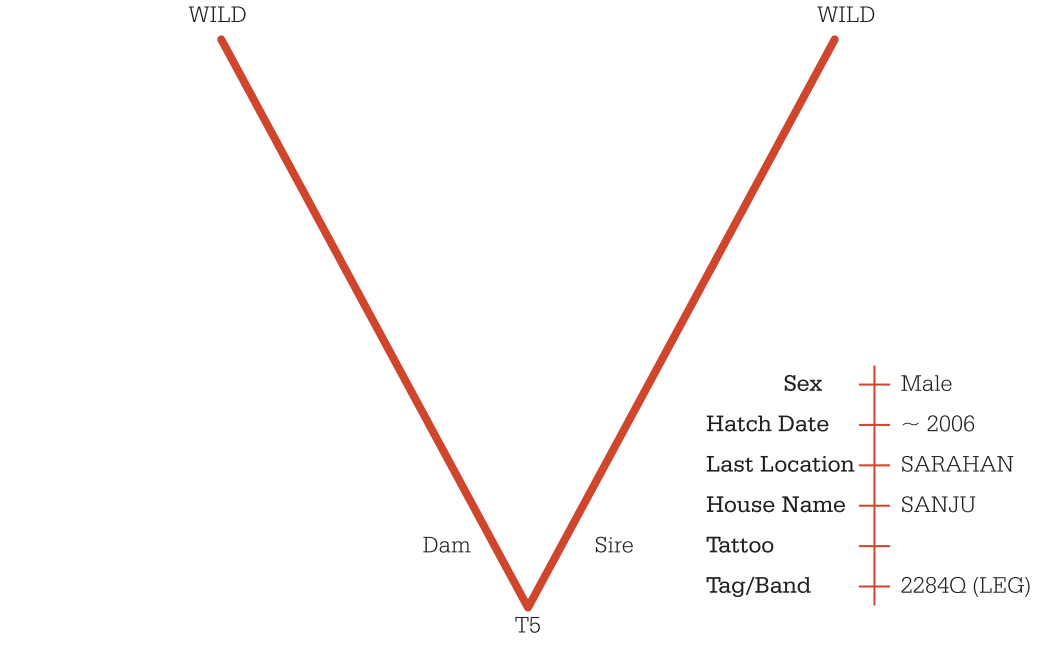

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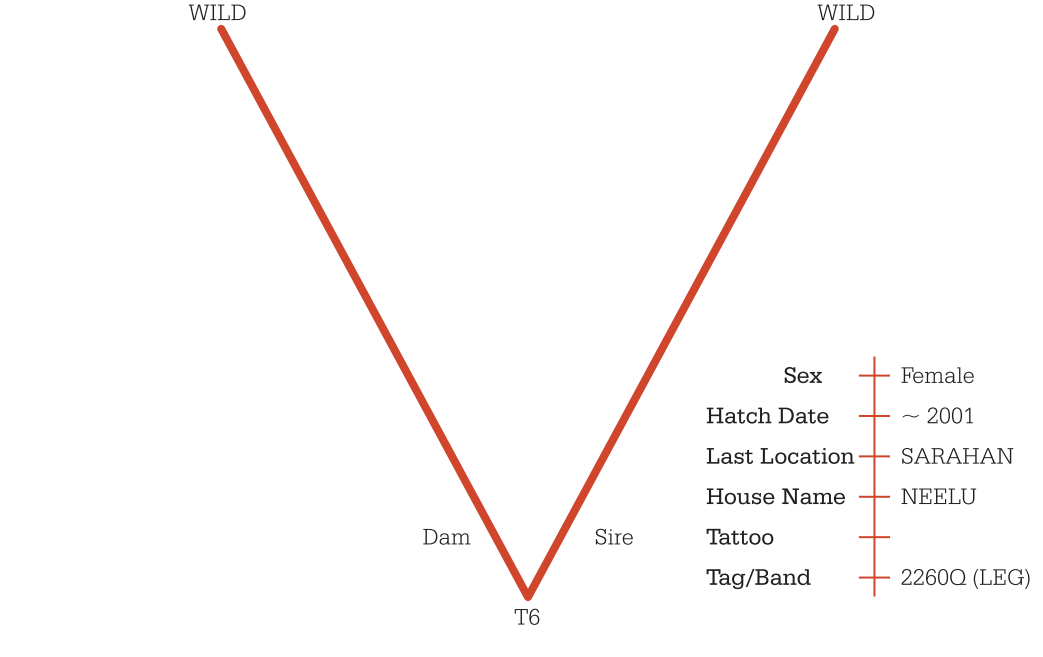

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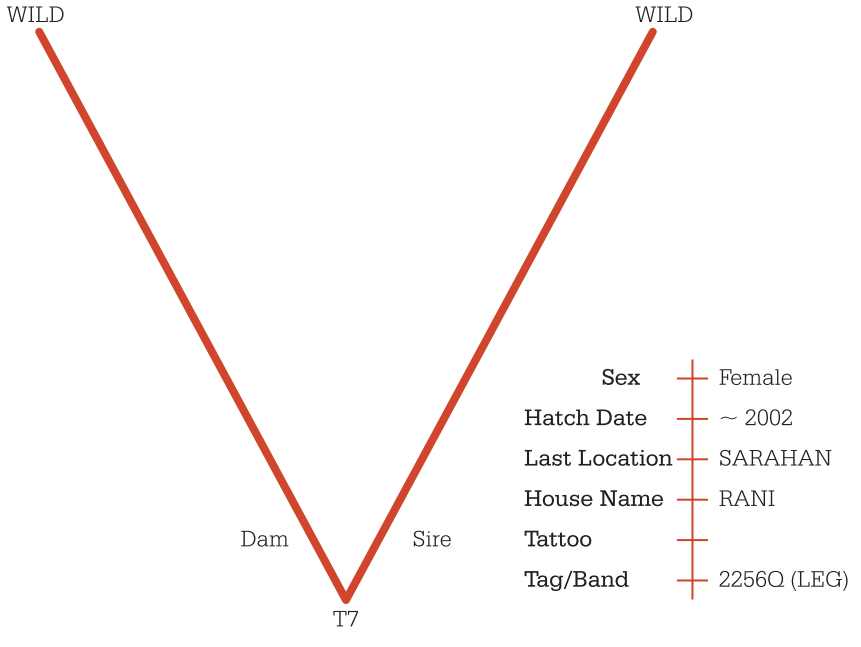

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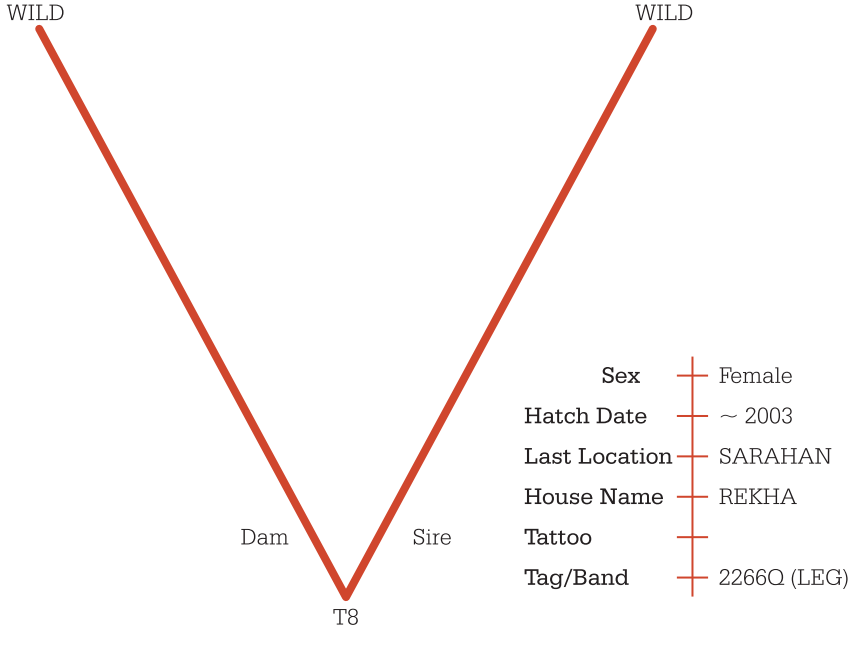

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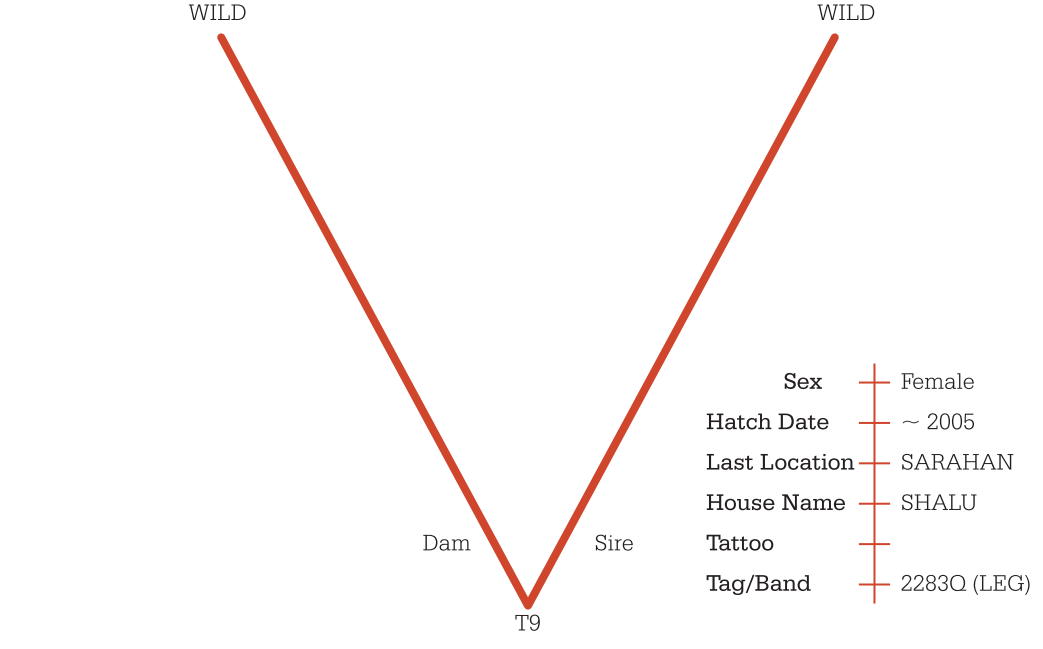

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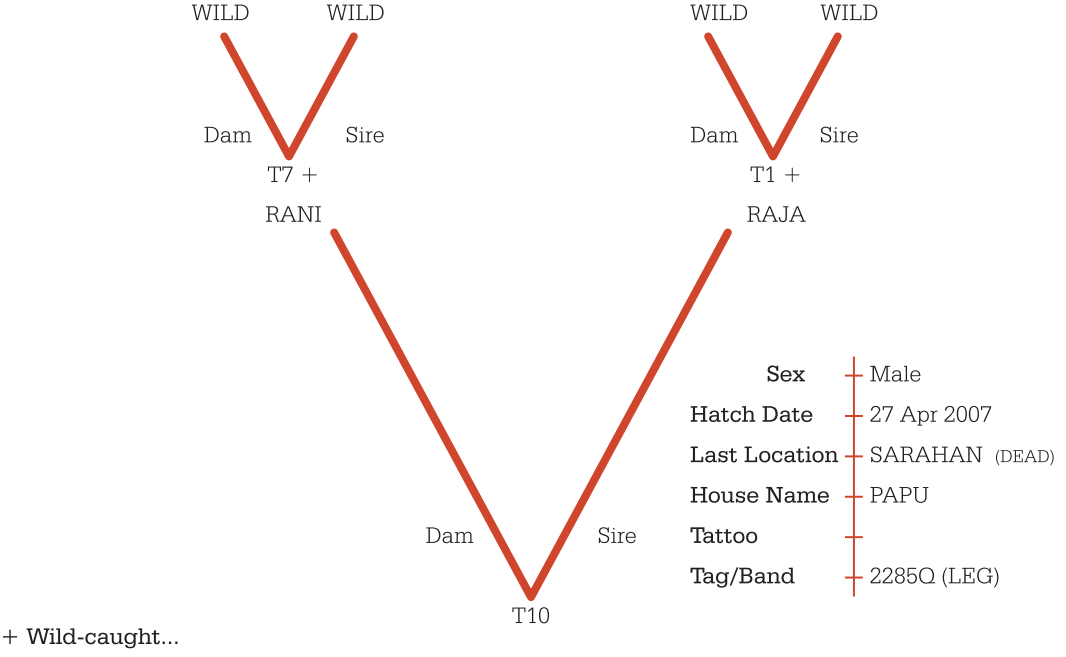

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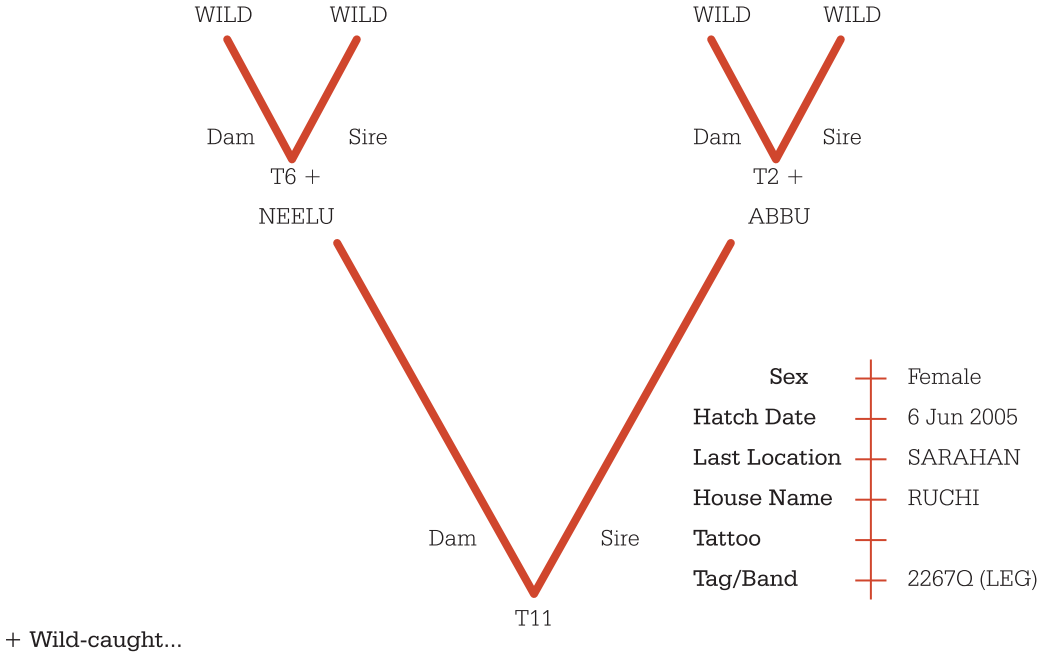

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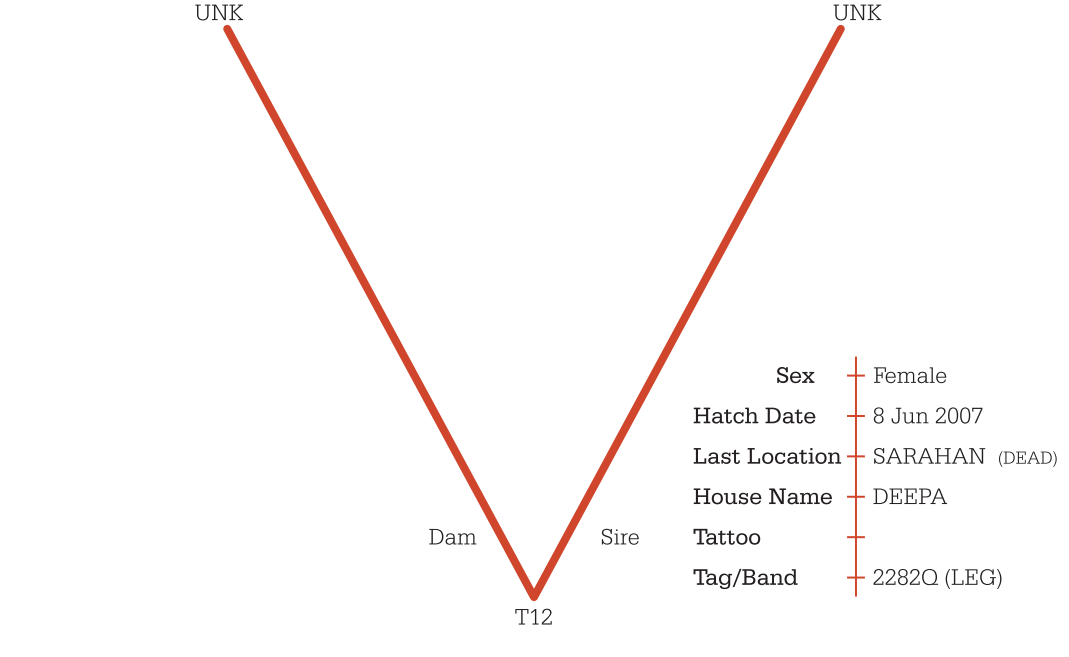

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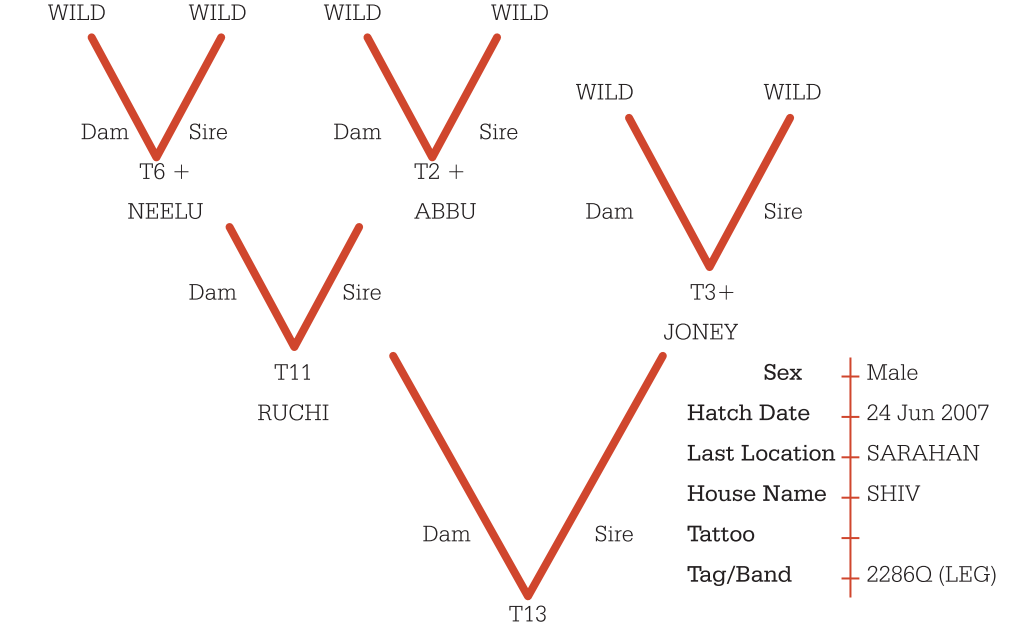

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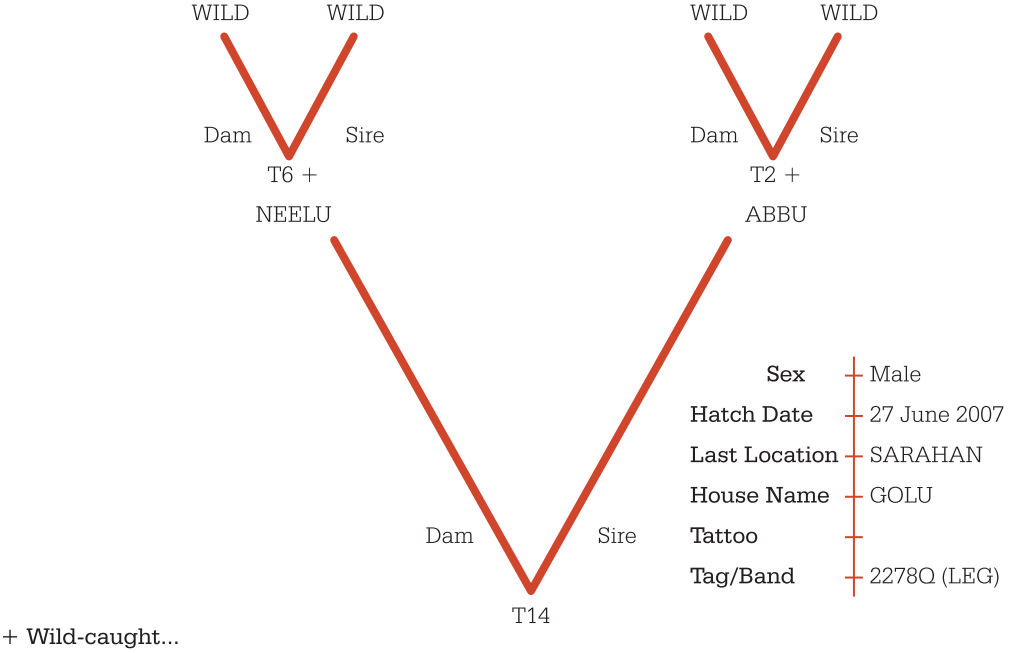

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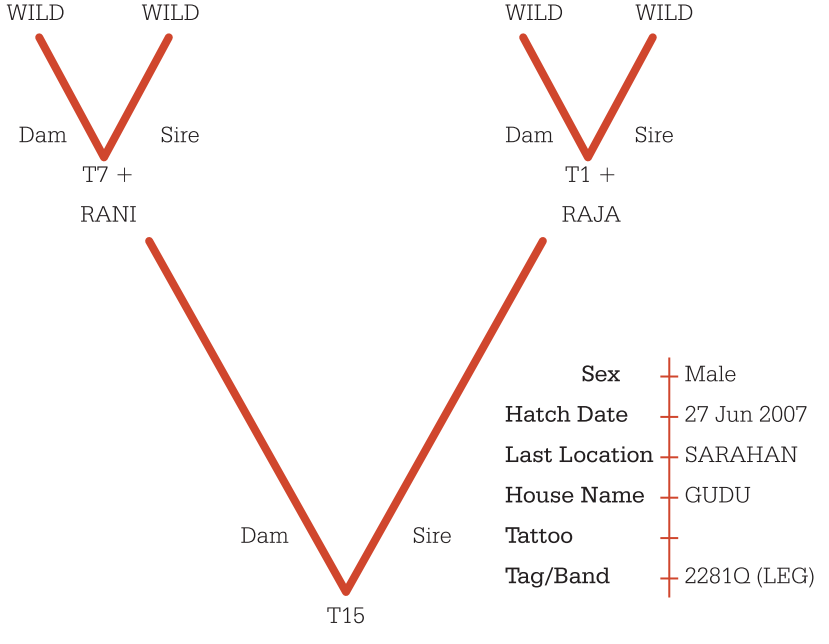

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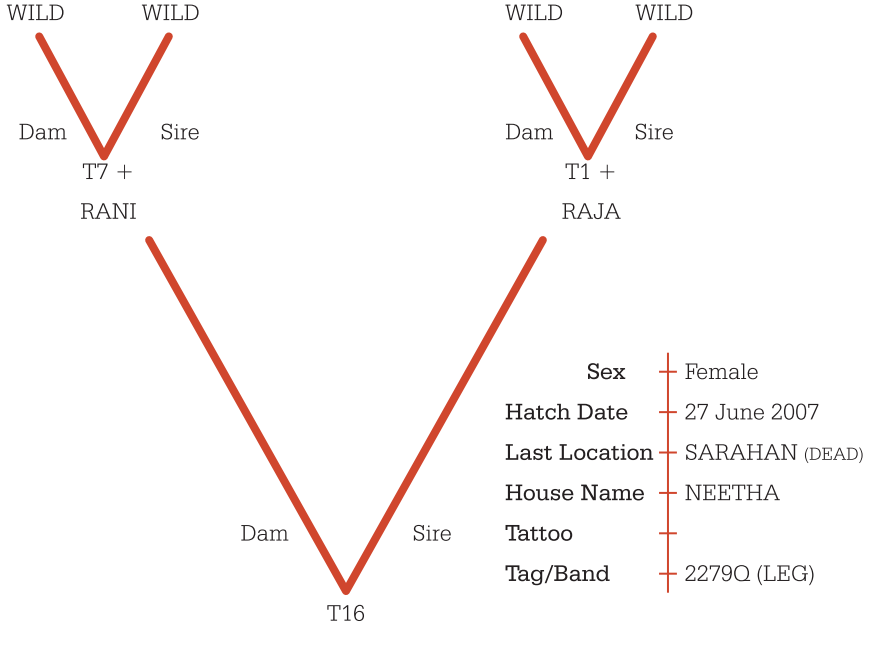

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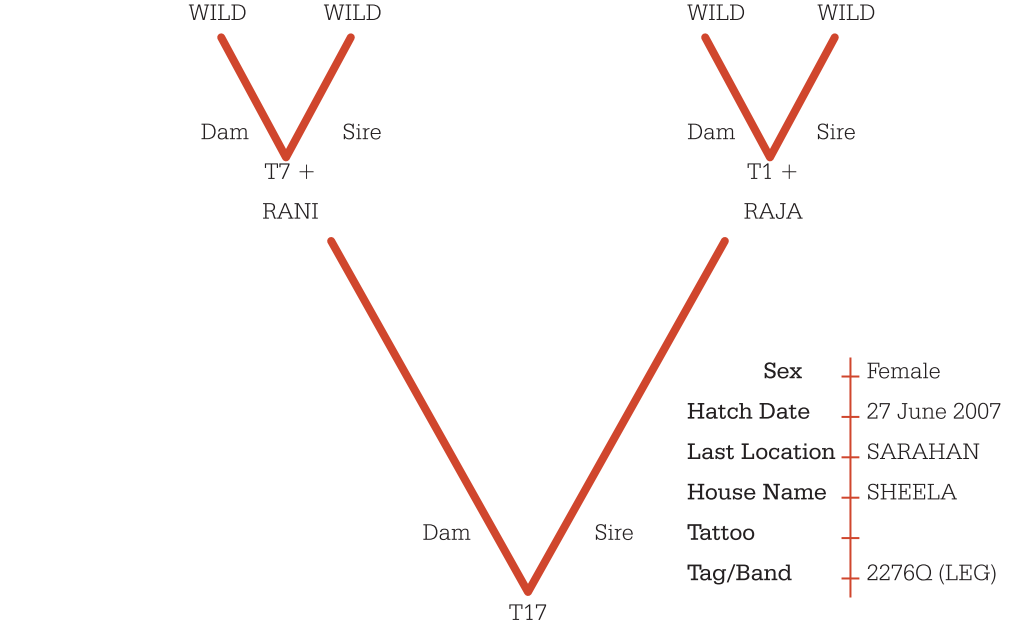

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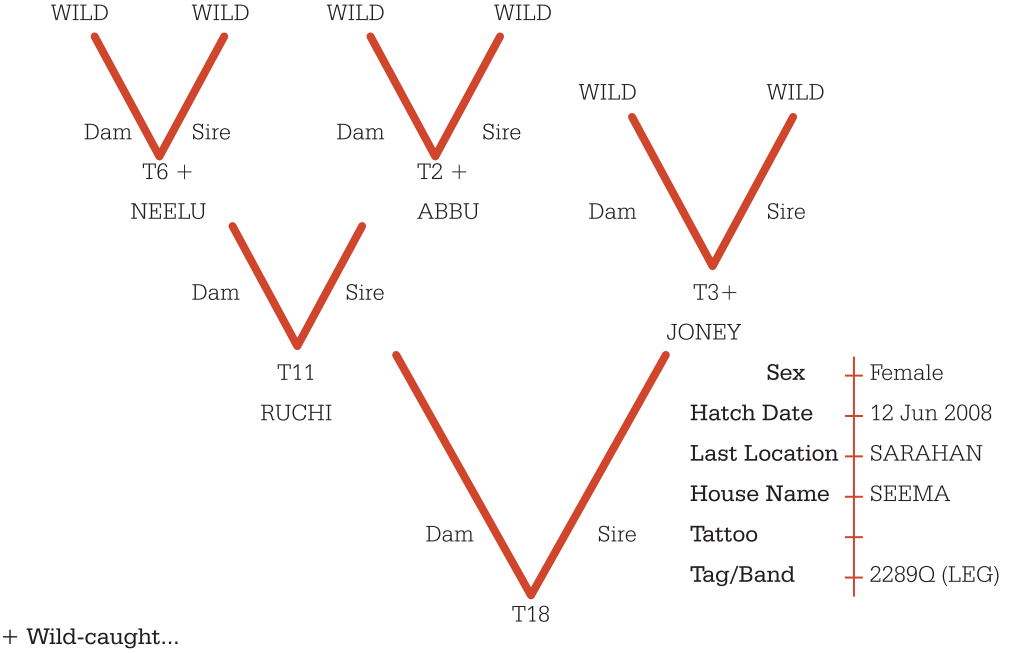

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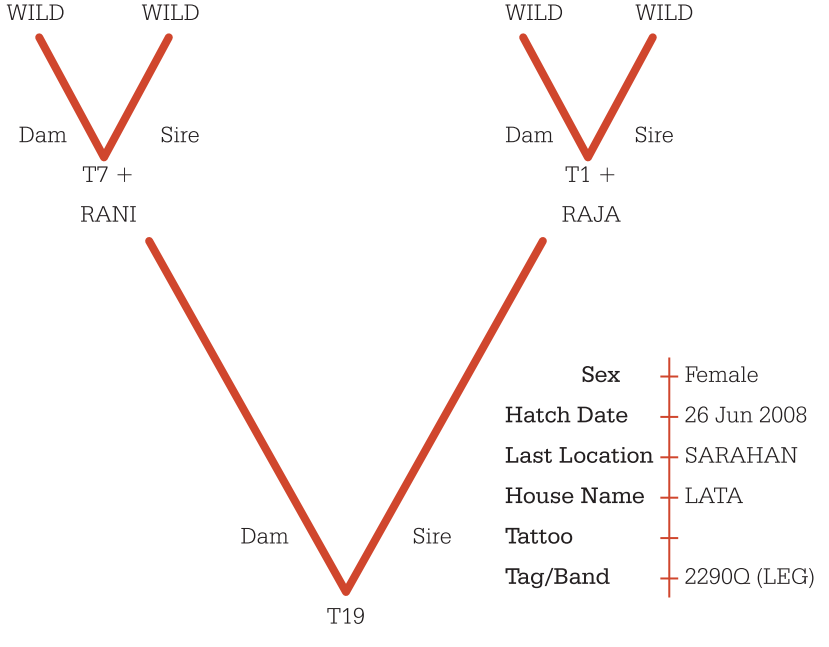

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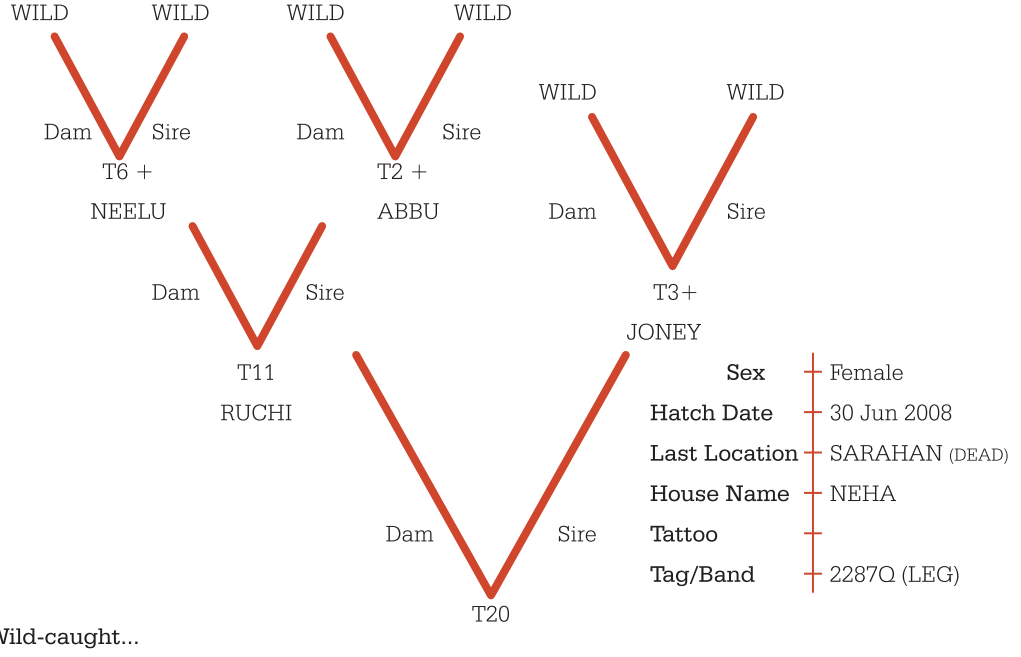

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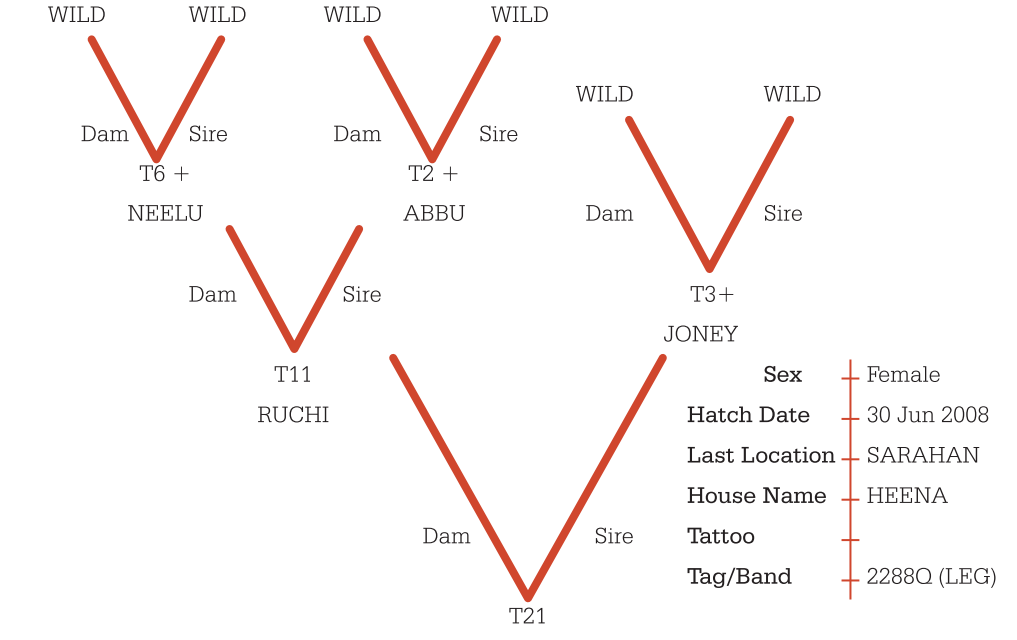

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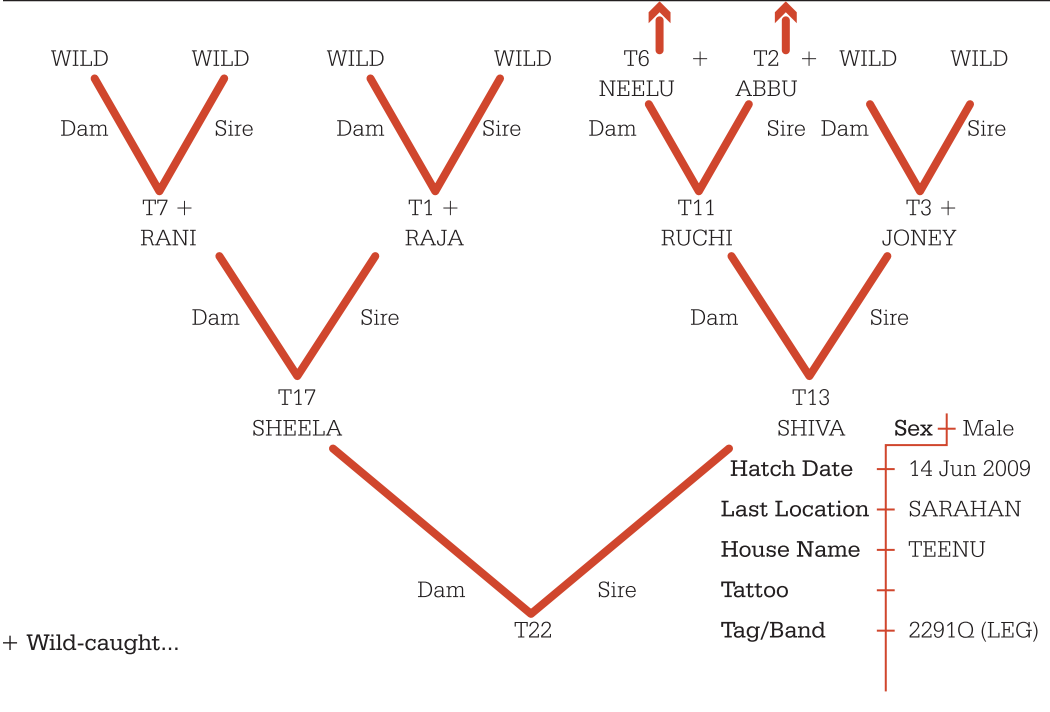

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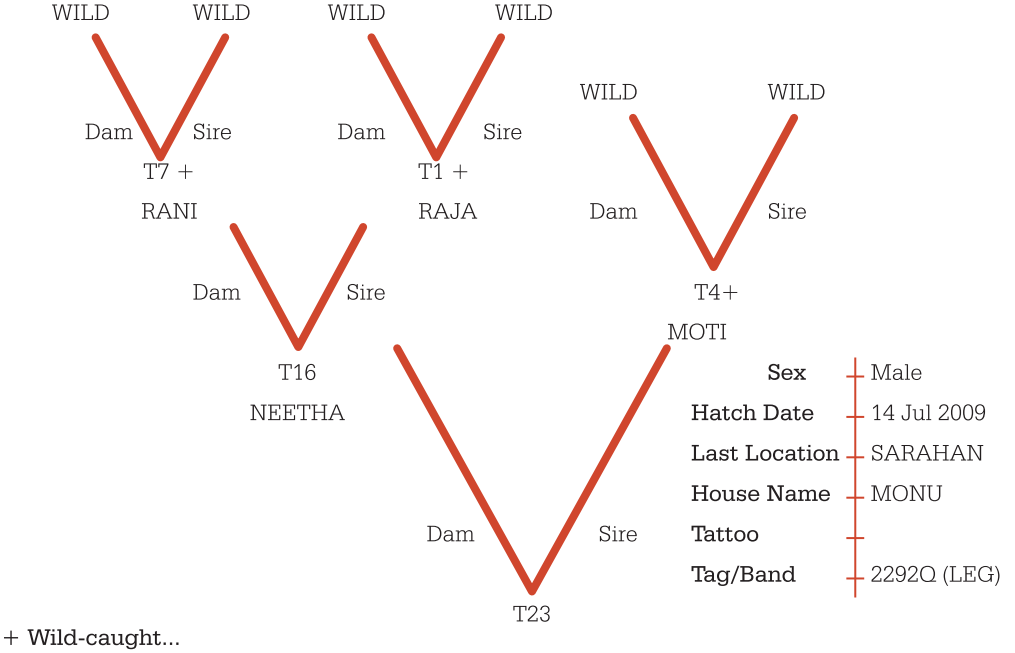

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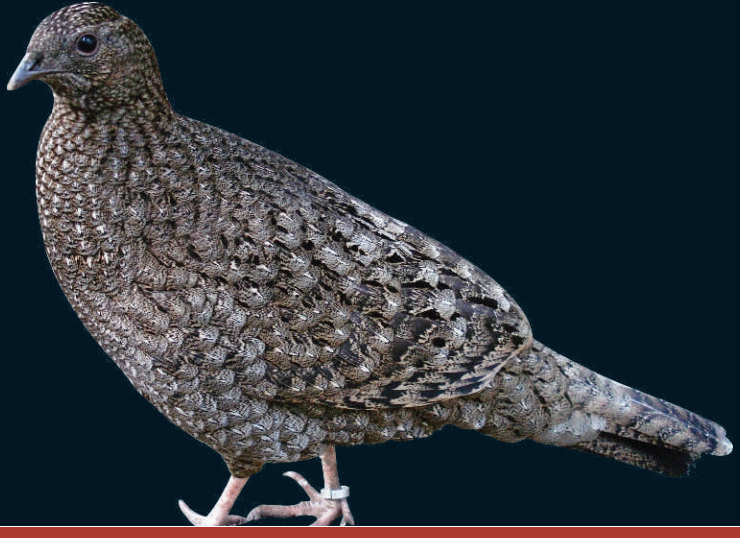

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भारतीय वन्यजीव संस्थान
Wildlife Institute of India
P. O. Box 18, Chandrabani
Dehradun- 248001
Uttarakhand
t. +91 135 2640111-115
f. +91 135 2640117
e. wii@wii.gov.in
www.wii.gov.in

Wildlife Wing, Forest Department
Government of Himachal Pradesh