

1 **Wildlife Biology**

2

3 **Title : Home range, daily movements, and site fidelity of male Reeves's Pheasants**

4 ***Syrnaticus reevesii* in the Dabie Mountains, central China**

5

6 **Short title: Home range and site fidelity of Reeves's Pheasants**

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23 **Key Words:** China, home range, movements, Reeves's Pheasant, site fidelity, *Syrnaticus reevesii*

1 **Abstract:** Reeves's Pheasant (*Syrnaticus reevesii*) is a threatened species endemic to China. From
2 April 2000 to August 2003, we studied home range size, daily movements, and site fidelity of 17
3 male Reeves's Pheasants at Dongzhai National Nature Reserve in central China. Average annual
4 home range size was 44.9 ± 24.6 ha (minimum convex polygon) and 23.8 ± 13.7 ha (95% fixed
5 kernel estimation). The average annual core area determined by 60% fixed kernel estimator was 4.2
6 ± 3.5 ha. Home range size was generally smaller in winter than in spring, whereas the size of the
7 core area remained stable through all seasons. Conifer-broadleaf forests occupied a very large part of
8 home ranges and core areas. Male pheasants exhibited strong site fidelity among seasons and years.
9 Our results provide baseline data for habitat management, habitat restoration, and reintroduction of
10 the Reeves's Pheasant.

11

12 **Introduction**

13 Seasonal differences in the use of space within an individual's home range, or in size, location,
14 and habitat composition of the home range may reflect changing habitat needs (Boyce 1979,
15 Aebischer et al. 1993, Philips et al. 1998, Judas and Henry 1999). Therefore, information on seasonal
16 variation in various aspects of a species' home range is important for understanding its biology and
17 establishing conservation strategies.

18 Reeves's Pheasant (*Syrnaticus reevesii*) is a threatened species endemic to China (Cheng et al.
19 1978, Cheng 1987). It inhabits broadleaf habitats dominated by oaks (*Quercus* spp.) in subtropical
20 forests with a dense canopy and sparse undergrowth between 200 and 2600 m elevation (Xu et al.
21 1991, Wu et al. 1994). Historically, the species was widely distributed and relatively common in
22 central China (Cheng et al. 1978), but the species has been extirpated from much of its historical
23 range in China due to illegal hunting and habitat degradation and loss (Xu et al. 1991, 1995,
24 MacKinnon et al. 1996, Zheng and Wang 1998). It is classified as a vulnerable species by the
25 IUCN's Red List (IUCN 2006) and a nationally second-class protected wildlife species in China
26 (State Council 1988). Nature reserves and habitat restoration in its historic range are likely necessary
27 to protect and perpetuate this species (Madge and McGowan 2002, Zhang et al. 2003). Considerable
28 information is available on the species' habitat (Wu et al. 1994), winter habitat use (Fang and Ding

1 1997; Sun et al. 2001; Sun et al. 2002; Xu et al. 2002, 2005, 2006, 2007), but our knowledge of
2 home range (Sun et al. 2003, Xu et al. 2005), daily movement patterns, and site fidelity of
3 Reeves's Pheasant is still limited and inconclusive (Wu 1979, Hu and Wang 1981, Fang and Ding
4 1997), creating difficulties in establishing scientific and effective conservation strategies for the
5 species.

6 As a part of a larger project examining the habitat use and spatial distribution of the Reeves's
7 Pheasant for establishing effective habitat management and restoration strategies, we examined
8 home range, daily movement, and their seasonal variations using radio-telemetry. Our main
9 objectives were to: 1) estimate home range size, 2) quantify daily movements, 3) investigate
10 seasonal variations in size of home ranges, and 4) examine home range fidelity among seasons and
11 years.

12

13 **Methods**

14 *Study site*

15 We selected a study site in Dongzhai National Nature Reserve (31°40'N, 114°24'E), a former
16 forest farm located on the northern slopes of the Dabie Mountain range in Henan Province of central
17 China (Figure 1) as this area comprises the major portion of the existing eastern distribution of
18 Reeves's Pheasant in China (Zheng and Wang 1998, Xu et al. 2007).. The reserve is located in the
19 northern subtropical zone where natural vegetation is characterized by mature forests dominated by
20 oaks *Quercus* spp., masson pine *Pinus massoniana*, dyetree *Platycarya strobilacea*, beautiful
21 sweetgum *Liquidambar formosana*, and Hupeh rosewood *Dalbergia hupeana*. Mature coniferous
22 plantations dominated by Chinese fir *Cunninghamia lanceolata*, shrubby areas dominated by young
23 oaks, young Chinese firs, and glaucous allspice *Lindera glauca*, tea *Camellia* spp. gardens, and
24 young plantations of Chinese fir occur in the study area.

25 Because Reeves's Pheasants are concentrated mainly in the core areas of this reserve (Song and
26 Qu 1996; Xu et al. 2006, 2007), we selected a 400 ha part of the core area at Baiyun as the study
27 area (Figure 1). Elevations at the site range from 100 m to 446 m, and the climate is warm and

1 humid, with mean annual temperature of 15.1°C (range: 13.2 - 40.1°C) and mean annual
2 precipitation of 1209 mm. Habitat types within the study area (Figure 1) included conifer-broadleaf
3 mixed forests (50%), broadleaf forests (14%), Masson pine forests (6%), planted Chinese fir forests
4 (16%), young fir forests (6%), shrubs (8%), and farmland (1%) (Xu et al. 2007).

5

6 ***Capture and radio tracking***

7 We used about thirty foot-hold traps placed around a decoy to capture male Reeves's Pheasants
8 during April and May of 2000 to 2002 (Sun et al. 2003). On average, we trapped for about 20 days
9 each year with at least 10 attempts on each trapping day. Each captured bird was fitted with a
10 coloured plastic leg band and a necklace radio transmitter (Biotrack Ltd, UK) with frequencies
11 between 216.00 and 217.00 MHz. Transmitter mass (16 grams) was < 2% of average pheasant body
12 mass (1641.1 ± 117.6 grams, mean \pm 1 SD, n = 17), and therefore likely had minimal effect on bird
13 behaviour (Kenward 2001).

14 Radio-tagged pheasants were located using a portable TR-4 receiver and a Telonics hand-held
15 three-element Yagi antenna. Bird locations were determined once or twice each day by triangulation
16 from permanent reference points within a randomly selected two-hour segment between 05:00 and
17 19:30 or by direct observation. In most instances (>95%) the distance from observer to pheasant was
18 less than 200 m. To reduce telemetry errors, all azimuths were collected within a three minute period
19 and triangulation angles were between 45° and 135° (Kenward 2001). The time between consecutive
20 radiolocations averaged 12 h (range from about 8 h to 16 h), normally resulting in two observations
21 daily. Bird positions were then determined using a global positioning system (GPS, GARMIN
22 12XL).

23 To estimate telemetry error, we placed transmitters in the study site and recorded their location
24 with GPS (GARMIN 12XL) and on a topography map. Then a naïve observer located these
25 transmitters using the same triangulation procedure used for locating birds. The distance between
26 these two locations for each transmitter was calculated as the telemetry error (Koehler and Pierce
27 2003). We compared the size of $CEP_{0.50}$, i.e. the median Circular Error Probable (Moen et al. 1997),

1 to the home range area, to assure telemetry errors were acceptable for home range analysis (Moser
2 and Garton 2007). Bird locations were divided into four seasons: spring (March-May), which
3 encompassed most mating activity; summer (June-August), when most females were rearing broods;
4 autumn (September-November), when young were still associated with their female parent; and
5 winter (December-February), when birds gathered into flocks.

6 7 *Data analyses*

8 Home range was estimated based on 100% minimum convex polygon (MCP) and 95% fixed
9 kernel estimation using Animal Movement software, an extension to ArcView 3.2, based on detected
10 locations (Hooge and Eichenlaub 1997). We defined 60% fixed kernel as the core area. All fixed
11 kernel estimations were based on least squares cross validation for deriving smoothing factor (Hooge
12 and Eichenlaub 1997). MCP has commonly been used to estimate home range but is sensitive to
13 sample size, and we reported MCP estimates on annual home range only to draw comparisons
14 between our findings and those of previous studies. The fixed kernel estimator is preferred because it
15 is based on nonparametric assumptions and more accurate relative to other home-range estimators
16 (Seaman and Powell 1996). Therefore, we used the home range size obtained by 95% fixed kernel
17 contours for additional analyses. Seasonal home ranges and core areas were estimated for individuals
18 with ≥ 30 locations in a season, while the annual home ranges and core areas were estimated for
19 individuals with ≥ 30 or more locations in a year. Average distance between consecutive locations
20 (every 12 hrs) was calculated and used as an index of daily mobility for each individual (hereafter;
21 daily movement) (Vega Rivera et al. 2003, Cardinal and Paxton 2005).

22 Home range composition was estimated based on the land cover map (Xu et al. 2007) in
23 Arcview 3.2. We used two measurements to quantify site fidelity: FIDELH is the percentage of an
24 individual's home range within the home range of the previous season or year (Phillips et al. 1998,
25 Perelberg et al. 2003); and FIEDLL is the percentage of an individual's locations within the home
26 range of the previous season or year (Phillips et al. 1998).

27 We were not able to test for year effect because of small sample size in each year, and pooled
28 radiolocations from 2000 to 2003 to ensure adequate sample size for seasonal analysis. We assumed

1 the yearly effect was small because habitat remained relatively unchanged (Xu, *unpublished data*)
2 and human disturbances were relatively constant because the study site is a protected nature reserve.
3 We used only one year of data for birds tracked more than one year when we estimated seasonal
4 variations of home range, core area, and movement. Values of home ranges and core areas were
5 natural log-transformed to meet assumptions of normality. One-way ANOVA was used to test
6 whether the home range areas, core areas, and daily movements differed among seasons. Tukey *post*
7 *hoc* tests were used for pair-wise comparisons. Seasonal changes in home range size were also
8 assessed with linear and quadratic trends. Pearson correlation was used to test the relationship
9 between the home range and core area among seasons and years.

10 We used an α level of $P \leq 0.05$ for all statistical tests. Unless otherwise mentioned, means are
11 provided with ± 1 standard deviation (SD). Statistical analyses were performed using SPSS 10.0.1
12 for Windows (SPSS Inc. 1999).

13

14 **Results**

15 ***Home range and core area***

16 Seventeen male Reeves's Pheasants were captured (9, 5, and 3 individuals in April 2000, 2001
17 and 2002, respectively), which represented about 15% of the male population at the study site¹. The
18 average tracking duration of each bird was 174.0 ± 150.2 days (range = 2 to 536 days). We assessed
19 accuracy of telemetry by comparing coordinates of 72 known points with those estimated using
20 telemetry. The average telemetry location error was 10.30 ± 5.28 m (mean ± 1 SD), and the size of
21 $CEP_{0.50}$ was 0.03 ha, which was small compared to the home range. Therefore, our telemetry
22 locations were reliable for estimating home range (Moser and Garton 2007). Annual average home
23 range size was 44.9 ± 24.6 ha based on minimum convex polygons, and 23.8 ± 13.7 ha ($N = 15$)
24 based on 95% fixed kernel estimator. Home range overlaps were common (Figure 1). Core area was
25 4.2 ± 3.5 ha ($N = 15$), accounting for $17.1 \pm 6.1\%$ of the corresponding home range. Core area size
26 was positively related to home range size ($r = 0.87$, $P = 0.001$). Home range size varied among

¹ Zhang, Z. W. (2002) *Survey of the habitat fragmentation of Reeves's pheasant*. Unpublished Small Grant Report to WWF-China. Pp16.

1 seasons ($F_{3, 29} = 2.22$, $P = 0.05$, Table 1) and declined linearly from spring to winter ($P = 0.02$).
2 Home range size differed significantly (Tukey HSD, $P = 0.03$) between spring and winter, but did
3 not differ among winter, summer, and autumn (Tukey HSD, winter vs. summer, $P = 0.180$; winter vs.
4 autumn, $P = 0.39$). Core area (Table 1) tended to increase from spring to summer and decreased in
5 autumn and winter ($F = 1.99$, $P = 0.14$); there was linear trend from spring to winter ($P = 0.04$).

6 Conifer-broadleaf mixed forests occupied the largest part of both the home range and core area
7 of male Reeve's Pheasants, followed by Chinese fir forests, broadleaf forests, masson pine
8 plantations, shrubs, and young replanted plantations (Table 2).

10 ***Movements and fidelity***

11 Daily movements (Table 1), measured as the distance between two consecutive locations
12 detected in approximately 12 hr intervals, differed by seasons ($F_{3, 29} = 4.90$, $P = 0.01$). Daily
13 movements showed a decreasing trend from spring to winter ($P = 0.01$). Daily movements in spring
14 were almost twice (Turkey HSD, $P = 0.004$) that of winter, but there were no differences among
15 winter, summer, and autumn distances (Tukey HSD, winter vs. summer, $P = 0.105$; winter vs.
16 autumn, $P = 0.29$). .

17 For 5 males that were radio-tracked in consecutive years, we found that on average, $61.0 \pm$
18 17.7% of their home range and $86.2 \pm 16.7\%$ of their detections in a given year were within the
19 home range of previous year. Home range overlap among seasons of each individual tended to
20 increase from spring to winter (Table 3): $65.9 \pm 15.8\%$ between spring and summer and $74.0 \pm$
21 18.8% between fall and winter.

23 **Discussion**

24 Although some information is available on home ranges of Reeves's Pheasant (Sun et al.
25 2003, Xu et al. 2005), and seasonal habitat use based on compositional analysis (Xu et al. 2007),
26 little has been published on home range attributes, including home range composition, daily
27 movements, and site fidelity. This information is important for successful conservation of Reeves's
28 Pheasant (Phillips et al. 1998, Perelberg et al. 2003, Mori 2005).

1 Estimating home range can provide vital insight into important ecological processes (Horne and
2 Garton 2006). Studies on Cabot's Tragopan (*Tragopan caboti*) (Young et al. 1991) and Ring-necked
3 Pheasants (*Phasianus colchicus*) (Smith et al. 1999) have shown that home range size varied
4 seasonally and was larger in spring compared to other seasons, particularly winter. Our results
5 indicated a similar pattern for male Reeves's Pheasants. The larger spring home range of male
6 Reeves's Pheasants could be related to several factors including: (1) mate-searching, (2) defense of
7 territories, and (3) securing food resources for increased energetic demands associated with the
8 breeding season. Smaller winter home ranges may result from a trade-off between food requirements
9 and cover needed to protect against increased predation. During winter, male Reeves's Pheasants
10 decrease activity, concentrating within optimal habitats, e.g. shrubs and mixed forests (Xu et al.
11 2007), likely resulting in smaller home ranges.

12 Core areas are areas of concentrated use (Somers and Nel 2004), often with the most dependable
13 resources (Leuthold 1977), and of great importance to individuals regardless of the season. Core
14 areas of Reeves's Pheasants in this study were often composed of conifer-broadleaf mixed forest.
15 This type of forest provides stable food resources for Reeves's Pheasants including buds in spring
16 and acorns in autumn and winter (Xu et al. 2007). This may explain the relative stability of core
17 areas across season.

18 We observed high overlap in a given pheasant's home range among years and seasons. This
19 pattern is inconsistent with results published by Fang and Ding (1997) who reported that Reeves's
20 Pheasants showed altitudinal movements across seasons, but agree with studies by Wu (1979) and
21 Hu and Wang (1981) who reported that Reeves's Pheasants did not shift their home range across
22 seasons. It may imply that resources at our study site were relatively stable across years and seasons,
23 and met the needs of Reeves's Pheasant. Habitat use by Reeves's Pheasant in this study was
24 relatively similar across seasons, and birds concentrated their activities mainly in conifer-broadleaf
25 mixed forests (Xu et al. 2007), suggesting that habitats within core areas were sufficient to support
26 birds' year-round activities.

27

28 **Conclusions**

1 Currently, there is a scarcity of knowledge about home range composition, daily movement, and
2 site fidelity of the Reeves's Pheasant, limiting the establishment of effective conservation strategies.
3 Our results provide baseline data regarding the spatial ecology of this endangered species.
4 Conservation management of the Reeves's Pheasant often involves establishing protected areas and
5 restoring existing habitat (Madge and McGowan 2002, Zhang et al. 2003). Our results showed that
6 the home range size of Reeves's Pheasant became smaller from spring to winter, and that Reeves's
7 Pheasants were most active in spring, suggesting that major habitat management activities should
8 avoid the most active period, i.e. spring. Because pheasant core areas remained stable across seasons,
9 resource managers should strive to maintain the spatial continuity of habitat composition in core
10 areas. Moreover, the strong site fidelity of male Reeves's Pheasants may make them particularly
11 susceptible to habitat change or loss, and creating additional habitat may be insufficient without
12 translocation since they are unlikely to colonize.

13

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1 Table 1. Seasonal home range, core area and daily mobility of male Reeves's Pheasant in
 2 central China.

Season	Individuals ¹	Home range (ha) ¹		Core area (ha) ¹		Daily mobility (m) ¹
		(95% fixed	Kernel)	(60% fixed	Kernel)	
Spring	12	23.9 ± 13.7		4.5 ± 3.2		233.6 ± 80.9
Summer	9	21.8 ± 13.4		5.3 ± 3.6		191.2 ± 50.2
Autumn	6	16.9 ± 7.7		3.0 ± 1.2		179.3 ± 41.9
Winter	5	9.5 ± 4.3		1.9 ± 0.8		132.3 ± 18.8

3 ¹ mean ± 1 standard deviation (SD).

1 Table 2. Home range and core area composition of male Reeves's Pheasant in central
 2 China.

Code	Season	Mixed ¹	Broadleaf ¹	Pine ²	Fir ³	Shrub ¹	Replanted ⁴	Farmland ¹
Home range	Spring	59.39±7.74	6.78±4.74	4.90±6.64	21.36±7.92	6.46±2.96	1.11±1.21	0.01
	Summer	59.75±18.82	7.36±5.94	4.84±7.94	19.89±8.25	5.31±5.07	2.86±6.28	0.01
	Autumn	56.13±21.31	7.16±5.65	4.75±6.88	20.40±7.23	8.19±6.35	3.38±6.69	-
	Winter	55.73±25.78	5.45±3.65	8.99±13.65	11.86±5.36	15.90±20.02	2.07±4.30	-
Core area	Spring	64.34±22.12	5.41±10.67	7.46±9.56	17.62±18.40	3.83±4.85	1.34±3.49	-
	Summer	64.24±28.08	1.40±2.77	6.65±9.84	19.92±19.32	4.57±7.56	3.22±9.14	-
	Autumn	64.11±30.69	5.12±7.13	6.02±9.77	11.66±8.50	11.36±20.23	1.74±4.25	-
	Winter	63.85±34.54	0.15±0.34	12.52±17.97	12.12±16.61	10.25±15.85	1.12±2.50	-

3 ¹ Mixed includes conifer-broadleaf mixed forests, broadleaf means broadleaf forests.

4 ² Masson pine forests.

5 ³ Chinese fir forests.

6 ⁴ Replanted means young Chinese fir forests.

1 Table 3. Seasonal site fidelity of the male Reeves's Pheasants in Dongzhai NNR.

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Measures of site			
fidelity	Summer vs. Spring	Autumn vs. Summer	Winter vs. Autumn
	65.92 ± 15.76	66.20 ± 13.59	74.02 ± 18.84
FIDELH ¹ (%)	(N = 8) ³	(N = 6) ³	(N = 5) ³
	73.50 ± 19.23	63.79 ± 17.58	75.49 ± 7.55
FIDELL ² (%)	(N = 8) ³	(N = 6) ³	(N = 5) ³

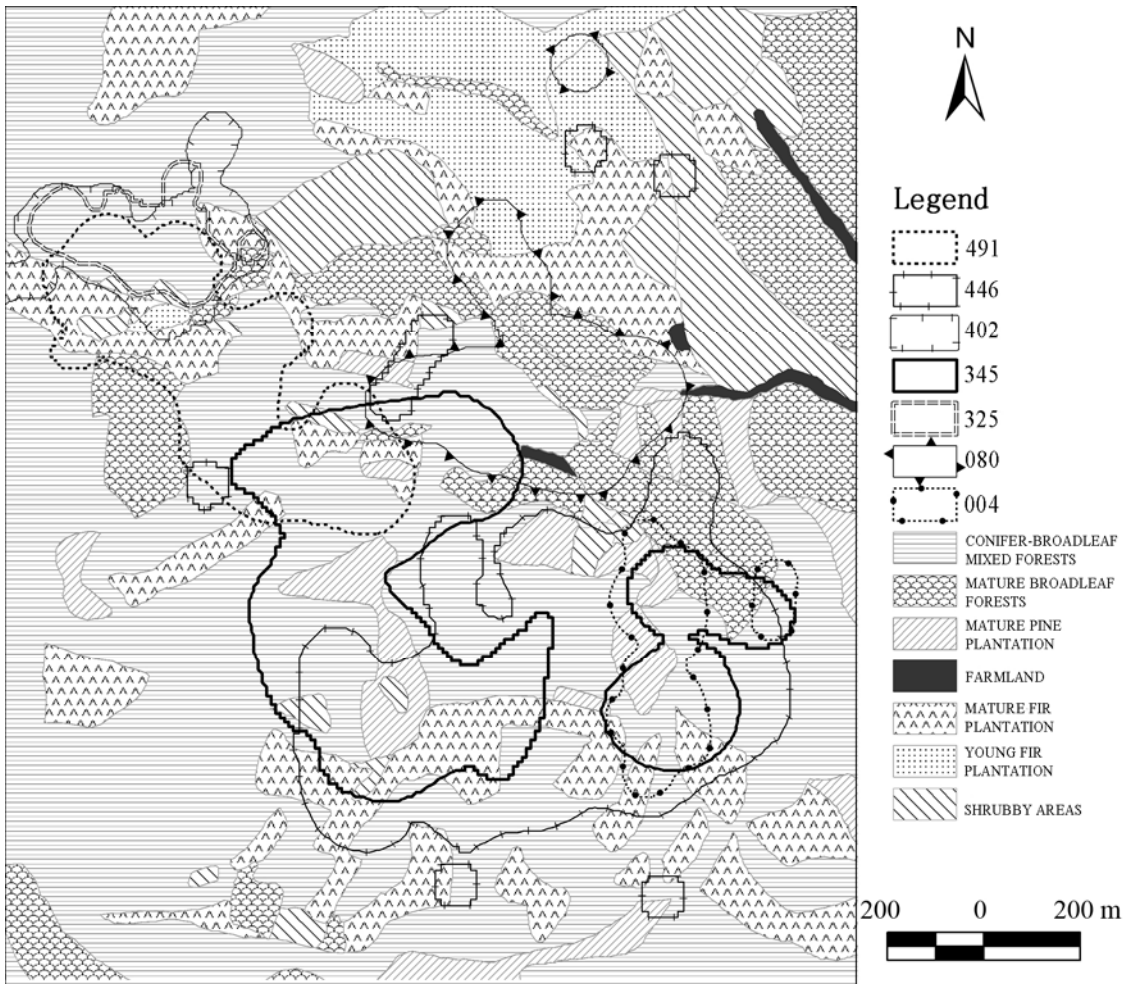
3 ¹ FIDELH = the percentage of an individual's home range within the home range of the previous season.

4 ² FIDELL = the percentage of an individual's detected locations within the home range of the previous
 5 season.

6 ³ N = the sample size of each season pairs.

- 1 Figure legend
- 2 Figure 1. Habitat types and home range contours of the tracked male Reeves's Pheasants in 2000 in the
- 3 study site in Dongzhai National Nature Reserve, Henan Province, China. The numbers in the legend
- 4 represent individual males.

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