Preliminary study on Alpine ibex (*Capra ibex ibex*, L.) and livestock distribution in Gran Paradiso National Park

M. Zurlo (1) (2), **E. Avanzinelli (3), B. Bassano (1) & N. Miraglia (4)**

(1) Gran Paradiso National Park, Via della Rocca 47, 10123 Torino, Italy
(2) Department of Biosciences, Università degli studi di Milano, Via Celoria 26, 20133 Milano, Italy
(3) Institute of Atmospheric Sciences and Climate, CNR, Corso Fiume 4, 10133 Torino, Italy
(4) Department of Agriculture, Environment and Feeds, Università degli studi del Molise, Via Francesco de Sanctis 1, 86100 Campobasso, Italy
Corresponding author: mikelezurlo@gmail.com

Introduction: Alpine ibex (Capra ibex ibex, L.) is currently classified at Least Concern by IUCN (International Union for Conservation of Nature, Temple and Terry, 2007). Considering the long time series of ibex population recorded in Gran Paradiso National Park (GPNP) a drastic decrease has occurred in the last decades. Causes are not completely clear but this decline could be linked to recent climate changes (Mignatti et al., 2012).

The aims are:

1) to evaluate the distribution of ibex in GPNP in 1985-2009 period and describe the livestock distribution in the same area in 2000-2009;
2) to assess the relation between the distribution pattern and ibex population trend in 2000-2009 in order to understand if species distribution is influenced by population dynamics or environmental processes.

Dataset description: Park area is divided in 36 surveillances zones with an average extension of 1100±185,2 ha (MEAN±SD). Since 1956 ibex population has been censused by the Park wardens according to sex/age classes and in 1985, using a monitoring unit of 250X250 m, they started to map the animal distribution in order to understand the characteristics of the selected territories. Since 2000 Park wardens have been collected also data about the livestock distribution. The present study refers only to three particular moment of ibex population trend: 1985-1987, 1992-1994, 1999-2009. Livestock data refer to 2000-2009 years.

The results showed a strong reduction (rs= -0,818; P<0,001) and fragmentation (rs= 0,784; P<0,001) of ibex occupied territories in 1985-2009 period. Table 2 shows that these results are confirmed by both scales of analysis. On the other side there was not a particular modification in livestock occupied territories and, using both scales of analysis, distribution values did not show a particular trend (P>0,05). Correlation test values between changes in ibex population and landscape metrics are listed in table 3. The relation between changes in ibex population trend and distribution patterns was not demonstrated by Spearman's rank correlation (all P>0,005).

Ibex distribution patterns

	Mean patch size				Total area		Number of patches		Radius of gyration				Patch cohesion index	
	250		500		250	500	250	500	250		500		250	500
YEAR	MPS±SD (ha)	CV (%)	MPS±SD (ha)	CV (%)	TA (ha)	TA (ha)	NP	NP	GYRATE± SD (m)	CV(%)	GYRATE± SD (m)	CV(%)	COHESION	COHESION
1985	35.29±35.	99.27	185.19±28	151.7	4587.5	10000	130	54	241.70±14	60.09	553.73±45	82.12	67.47	79.03
1987	37.54±42.	112.07	265.91±52	198.89	5368.75	11700	143	44	249.23±17	68.31	624.53±69	110.5	69.8	87.34
1992	40.00±49.	123.71	171.54±27	158.58	5400	11150	135	65	251.06±20	82.39	513.26±47	91.78	72.41	78.21
1993	29.18±45.	155.04	144.79±26	185.02	4668.75	10425	160	72	215.72±17	78.94	462.81±45	99.37	68.6	78.59
1994	28.53±40.	141.06	150.00±19	128.65	4393.75	10050	154	67	214.14±14	68.76	500.72±37	74.94	67.55	73.3
1999	23.11±26.	116.67	132.41±23	175.41	4575	10725	198	81	193.05±11	60.89	483.93±44	91.37	60.2	75.28
2000	12.28±11.	92.29	96.67±126	130.52	2800	8700	228	90	154.66±70	45.66	403.83±24	60.71	40.34	65.28
2001	12.27±11.	89.76	92.42±122	132.43	2943.75	9150	240	99	154.75±61	39.57	413.26±27	66.05	40.42	63.99
2002	13.30±18.	138.85	95.79±141	148.15	3018.75	9100	227	95	157.95±90	57.46	407.11±28	70.01	50.6	66.79
2003	13.60±19.	140.76	120.57±20	167.83	3181.25	9525	234	79	162.69±84	51.82	469.17±40	86.22	48.33	74.08
2004	12.45±15.	125.15	100.00±15	156.21	3025	9600	243	96	155.43±79	51.22	426.50±34	80.28	45.91	67.78
2005	13.20±18.	142.08	102.69±15	151.36	3181.25	9550	241	93	156.21±87	56.12	442.47±35	79.75	49.75	69.6
2006	12.47±16.	131.31	98.40±166	169.69	2918.75	9250	234	94	156.84±84	53.99	416.30±34	83.34	45.61	70.25
2007	12.21±16.	132.15	86.90±155	178.75	2906.25	9125	238	105	152.44±71	46.85	387.90±33	86.39	44.88	69.64
2008	10.82±9.4	87.12	89.05±111	125.49	2812.5	9350	260	105	149.93±62	41.99	408.37±26	64.17	35.82	63.61
2009	10.41±11.	113.34	85.05±106	125.16	2331.25	7825	224	92	144.18±56	39.01	415.24±28	69.58	35.67	62.7
r_s	-0.874, P<0.001		-0.862, P<0.001		-0.818, P<0.001	-0.700, P<0.001	0.784, P<0.001	0.808, P<0.001	-0.868, P<0.001		-0.712, P<0.001		-0.815, P<0.001	-0.765, P<0.001

Livestock distribution patterns

	Mean patch size				Total area		Number of patches		Radius of gyration				Patch cohesion index	
	250		500		250	500	250	500	250		500		250	500
YEAR	MPS±SD (ha)	CV(%)	MPS±SD (ha)	CV (%)	TA (ha)	TA (ha)	NP	NP	GYRATE±SD (m)	CV(%)	GYRATE±SD (m)	CV(%)	COHESION	COHESION
2000	25.26±48.84	193.30	108.06±201.35	186.32	2981.3	6700	118	62	196.95±144.47	73.36	409.37±317.06	77.45	66.19	74.19
2001	15.90±29.62	186.27	60.36±97.97	162.32	1606.3	4225	101	70	163.79±114.70	70.03	330.74±206.41	62.41	56.33	56.26
2002	30.42±65.80	216.34	86.36±130.06	150.6	912.5	1900	30	22	204.80±176.49	86.18	348.58±227.52	65.27	75.02	65.31
2003	35.29±70.78	200.59	126.25±158.47	125.52	3387.5	7575	96	60	245.31±252.76	103.04	467.28±338.21	72.38	75.68	69.49
2004	29.95±92.70	309.52	120.56±193.57	160.56	3593.8	7475	120	62	189.61±175.71	92.67	431.52±276.88	64.16	76.1	69.92
2005	30.72±73.73	239.98	114.58±180.99	157.95	2550	5500	83	48	203.07±207.69	102.27	417.51±297.87	71.34	76.22	70.34
2006	27.54±52.34	190.09	123.00±164.15	133.46	2781.3	6150	101	50	202.53±159.55	78.78	448.43±321.98	71.8	70.24	69.94
2007	13.06±16.31	124.92	80.00±90.00	112.5	1606.3	4800	123	60	158.39±80.81	51.02	370.74±209.47	56.5	46.22	61.23
2008	13.96±14.96	107.13	80.80±105.96	131.13	1550	4525	111	56	161.78±78.20	48.34	389.37±236.95	60.85	47.06	60.03
2009	14.52±22.33	153.78	84.00±131.41	156.44	1481.3	4200	102	50	160.60±94.51	58.85	381.12±275.09	72.18	54.26	66.93
r_s	-0.467, P>0.005		-0.139, P<0.005		-0.347, P>0.005	-0.236, P>0.005	0.255, P>0.005	-0.416, P>0.005	-0.539, P>0.005		0.07, P<0.001		-0.406, P>0.005	-0.212, P>0.005

Tab. 2-3 | The results of selected metrics. Values are listed according to spatial scales used (250 m and 500 m grid). For each index is reported the result of correlation coefficient to assess index trends.

Relation between ibex population and distribution pattern in 1999-2009 period

Δ	250	500
MPS-ibex pop.	r_s=0.285, P>0.005	r_s=0.067, P>0.005
TA-ibex pop.	r_s=0.261, P>0.005	r_s=0.182, P>0.005
NP-ibex pop.	r_s=0.188, P>0.005	r_s=0.182, P>0.005
GYRATE-ibex pop.	r_s=0.030, P>0.005	r_s=-0.152, P>0.005
COHESION-ibex pop.	r_s=0.382, P>0.005	r_s=-0.091, P>0.005

Tab. 4 | Results of correlation test between changes in ibex abundance (ibex pop.) and distribution pattern. Values are listed according to spatial scale.

Spatial pattern analysis: maps were created and pre-processed using QGIS 2.8 (Quantum GIS Development Team, 2015), while Fragstats (Mcgarigal, 2012) allowed to analyse the distribution patterns through different years. According to literature, the analysis was carried out using two different spatial scales, in order to explore the possible difference between the resultant of the two analysis (Turner et al., 1989). These are the 250 m grid cell available from census data and the 500 m grid cell created using census data.

Composition metrics		Spatial configuration metrics	
Patch size (MPS)	Area of each patch (ha)	Radius of gyration (GYRATE)	Measure of patch extent
Total area (TA)	Sum of each patch (ha)	Patch cohesion index (COHESION)	Measure of physical connectedness of patches
Number of patches (NP)	Number of patches		

Tab. 1 | Selected landscape metrics and relative unit of measure

Statistical analysis: following the patch-centric perspective, the distribution statistics selected to provide a statistical summaries of patch metrics are: mean, standard deviation and coefficient of variation (Mcgarigal 2012). The Spearman's rank correlation coefficient was used to test composition and configuration metric trends in 1985-2009 period. The same test was used also to assess if ibex population dynamics play a role in shaping distribution using changes in ibex abundance and distribution patterns values. Changes are Δ=t2-t1 where t are values in two consecutive years. The considered period for this kind of analysis was 1999-2009. The statistical analyses were performed using R 3.1.2 (R Development Core Team 2015).

Fig. 1 | Gran Paradiso National Park (GPNP)

Discussion and conclusions: the results show an effective change in Alpine ibex distribution while livestock distribution doesn't show any particular modification in selected periods. Considering the literature we can only suggest the factors affecting ibex distribution operating at different scales and we suppose that landscape modification (Gehrig-Fasel et al. 2007; Falcucci et al. 2006), climatic changes (Post et al. 2008; Pettorelli & Pelletier 2007) and anthropogenic disturbances (Iranzo et al. 2013; Hibert et al. 2010; Bagchi et al. 2004) play an important role in shaping ibex distribution.

These results highlight how the contrasting phenomena of land abandonment and pasture overgrazing tend to modify the Alps landscape with considerable effects on species distribution. In our human dominated landscape the nature conservation and maintenance of traditional activities are complementary objectives.

Fig. 2 | Male ibex. Source: GPNP archive

Fig. 3 | Female ibex and kid. Source: GPNP archive

Fig. 4 | Park wardens. Source: GPNP archive

Fig. 5 | Interaction between ibex and livestock.

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