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EFFECTS OF THE RISK OF INTRAGUILD PREDATION ON THE VOCAL ACTIVITY AND DETECTABILITY OF TENGMALM'S OWL (*AEGOLIUS FUNEREUS*)

EFFETTI DEL RISCHIO DI INTRAGUILD PREDATION SULL'ATTIVITÀ VOCALE E SULLA RILEVABILITÀ DELLA CIVETTA CAPOGROSSO (*AEGOLIUS FUNEREUS*)

Riassunto breve - La civetta capogrosso è vittima di predazione da parte del genere *Strix*. I risultati dello studio evidenziano come nelle aree di simpatria con l'allocco, l'attività di canto della civetta capogrosso sia condizionata più dalla competizione interspecifica che da quella intraspecifica. La depressione dell'attività di canto notturna e l'aumento dell'attività di canto diurno sembrano rappresentare una strategia comportamentale adattativa a breve termine per ridurre il rischio di predazione da parte del competitore. Alla luce dei risultati dello studio, appare necessaria particolare attenzione nel monitoraggio della distribuzione e abbondanza di civetta capogrosso nelle aree di simpatria. In un contesto di riscaldamento globale, la pressione competitiva dell'allocco potrebbe causare una contrazione dell'areale della civetta capogrosso, compromettendone il grado di conservazione nella rete Natura 2000 europea.

Parole chiave: Intraguild predation, competizione, canto territoriale, civetta capogrosso, grado di conservazione, rete Natura 2000.

Abstract - Tengmalm's Owl resulted to be victim of intraguild predation by *Strix* spp. The results suggest that in the areas of sympatry with Tawny Owl, the song of the Tengmalm's Owl is affected more by the inter-specific than by the intra-specific competition. The depression of the nocturnal singing activity and the increase of the diurnal song seem represent a short-term behavioural strategy to reduce the risk of predation, allowing the coexistence of intraguild prey and its killer. This evidence suggests particular attention should be taken in order to obtain reliable data on species distribution and abundance by surveying singing males occurrence. In a global warming context, the intraguild pressure of the Tawny Owl could cause a contraction in the range of Tengmalm's Owl, affecting its conservation status in the Nature 2000 network in Europe.

Key words: Intraguild predation, competition, territorial song, Tengmalm's Owl, conservation status, Nature 2000.

Introduction

Bird song has probably evolved through the intra- and inter-sexual selection, with the dual function of mate attraction and competing males repulsion, in order to defend other limited resources as well, such as food and nest (DARWIN 1871; CATCHPOLE 1982; SEARCY & ANDERSSON 1986; CATCHPOLE & SLATER 1995; GALEOTTI et al. 1997). The high costs of the song (LAMBRECHTS & DHONDT 1988; VEHCENCAMP et al. 1989; EBERHARDT 1994), in terms of spent energy, loss of time for food search, and exposure to predators, make the song a factor of selection, and therefore discloses the quality of the males.

According to the hypothesis of sexual selection of the "good genes" (TRIVERS 1972; ZAHAVI 1975, 1977; HALLIDAY 1978) the female selects her partner basing the choice on the signals that reveal the male's quality.

Some parameters of the song can serve as indicators of the male's qualities, of his health and both parasitological and hormonal levels (MØLLER 1991; ARNOLD 1975; GROSSMAN 1985; MARLER et al. 1988, JOHNSEN 1991; LAWRENCE 1991; KETTERSON & VAL NOLAN 1992; SAINO et al. 1995; GALEOTTI et al. 1997), of the food quality and availability (SEARCY 1979; GREIG-SMITH 1983; DAVIES & LUNDBERG 1984; GOTTLANDER 1987; REID 1987; STRAIN & MUMME 1988), and of the habitat quality (GARSON & HUNTER 1979; HIGGINS 1979; KROODSMA 1982; MORTON 1986; SANTEE & BAKKEN 1987).

Considering their nocturnal habits, it is probable that in the Strigiformes the song represents a particularly important communication instrument. The following characteristics probably highlight the importance of the song for the studied species: the reproductive biology of the Tengmalm's Owl is characterized by a frequent polygyny and polyandry, and by a seasonal pair tie,

rarely constant across the years (KONDRATZKI & ALTMULLER 1976; KORPIMÄKI 1981; Baudvin et al., 1995). Moreover, only in the years of greater food availability all the males are able to reproduce (KORPIMÄKI, 1981; BAUDVIN et al. 1995).

The song of the male can be considered as a compromise between the need to communicate with conspecifics of both sexes, the costs of song production, and the risks of being predated. Intraguild predation - the killing by a predator of species that use similar resources and are thus potential competitors - has been reported also in raptor assemblages (see review in SERGIO & HIRALDO 2008). In particular, Tengmalm's Owl resulted to be victim of intraguild predation by Ural Owl *Strix uralensis* (HAKKARAINEN & KORPIMÄKI 1996). The study of Hakkarainen and Korpimäki evidenced that the victim species tend to avoid areas in which the killer species are present. Other species show a short-term behavioural strategy to reduce the risk to be predated by their intraguild killer species. Little Owls *Athene noctua* became significantly more silent and fled to refuges in small cavities of trees or buildings after detection of a Barn Owl (ZUBEROGOITIA et al. 2007). In North America, the presence of Barred Owls may affect vocal behavior and detectability of Spotted Owls (OLSON et al. 2005; CROZIER et al. 2006). Studies carried out in the study area (BORGO 1999) pointed out that Tawny Owl and Tengmalm's Owl meet and overlap in a few forestal habitats of the mountain horizon. In this situation, the two species can be in competition for nest cavities and food (BAUDVIN et al. 1995). Tawny Owl is more than two times heavier than Tengmalm's Owl, and is therefore - following SERGIO & HIRALDO (2008) - a potential intraguild predator for Tengmalm's Owl, as noticed in France by BAUDVIN et al. (1995).

The aims of the present study, were to verify the environmental factors affecting the vocal activity of Tengmalm Owl, with particular attention to the potential effects of the nearness of Tawny Owl. I wanted to verify the hypothesis that an increase of the song costs, due to the increase of the risk of intraguild predation, can interfere with the needs of the intra-specific communication.

Study area

Data concerning the singing activity of the owls were collected during a triennial study (BORGO 1997, unpubl.) conducted in a 143 km² wide area of the Carnic Prealps and Friulian Dolomites, Italian Oriental Alps, Friuli-Venezia Giulia region, district of Pordenone (fig. 1). The study area is composed by two sample subareas and it is placed between the alpine and the prealpine districts, with 700-2660 m altitude range (fig. 1). The western sample area, 83 km² wide area, was investigated in 1995 and 1996, and is placed in the territory of Soverzene (BL,



Fig. 1 - Geographical location of the study area in the Friuli Venezia Giulia region (NE Italy).

- Posizione geografica dell'area di studio nel Friuli Venezia Giulia (Italia nordorientale).

Veneto region), Erto-Casso and Cimolais (PN, Frioul region); the second one, 60 km² wide area, is placed in the territory of Frisanco, Claut and Tramonti di Sopra (PN). The morphology of the study areas is characterised by large differences in altitude and high climatic differences between the southern and northern slopes. In the southern slopes, the sub-mountain (thermophile) phytocenosis can get to 1400 m of altitude, whereas in northern slopes it gets to 900-1000 m a.s.l. The 49% of the forest cover is represented by sub-mountain typologies, the 37% by mountain ones, and only the 14% by the sub-alpine. The Orno-ostrietum (forest of flowering ash *Fraxinus ornus* and hornbeam *Ostrya carpinifolia*) cover the 10.3% of the study area, the beech (*Fagus sylvatica*) sub-mountain forest the 13.8%, the mountain beech forest the 10.3%, the mountain Piceo-fagetum (mixed forest with beech, spruce *Picea abies* and fir *Abies alba*) 8.4%, and the sub-alpine spruce forest (spruce with larch *Larix decidua*) the 4.9%. The annual average temperature (measured at 600 m of altitude) during the study period was 9,3°C and the annual average precipitation was 1390 mm (BORGO 1997).

Methods

During a research about the birds of prey community of the Dolomiti Friulane Natural Park, 98 nights and 133 days of data collection were effected from 1995 to 1997. I censused Tengmalm Owl and Tawny Owl territorial males between February and June, during full-night surveys, by listening to spontaneous vocalizations. In each study area, I plotted a network of listening stations,

Variable	Description
SN/LN	Frequency of singing nights: calculated as the ratio of the number of singing nights (SN) of the male over the total number of listening nights (LN) of the same male
NS	Average nocturnal song of the male: calculated as the ratio of the total time (in minutes) of recorded nocturnal song over the number of recorded singing nights
%DS	Percentage of the song emitted by male during daytime
NND	Distance of the core area of the Tengmalm's Owl male to the nearest core area of a conspecific male
NNDTO	Distance of the core area of the Tengmalm's Owl male to the nearest core area of a Tawny Owl male
ALT	Altitude (m a.s.l.) of the core area
% Piceo-Fagetum	% Extent of Piceo-fagetum forest in a plot 1 Km ² wide centred on the core area of the male
% Subalpine spruce forest	% Extent of subalpine spruce forest in a plot 1 Km ² wide centred on the core area of the male
% Mountain beech forest	% Extent of mountain beech forest in a plot 1 Km ² wide centred on the core area of the male

Tab. I - Parameters of the vocal activity of the Tengmalm's Owl males (N=11) and environmental variables measured in the sample plots 1 km² wide centred on their core areas.

- *Parametri dell'attività di canto dei maschi di civetta capogrosso (N=11) e variabili ambientali misurate nelle aree campione da 1 km² centrate sulle loro core area.*

located 1.000-2.000 m apart, depending on local topography and acoustics, so as to cover the whole area. All plots were surveyed at least three times between February and June. The duration of each song was surveyed.

With the mappage method (BLONDEL 1969), 19 core areas of Tengmalm's Owl and 28 of Tawny Owl were located in the study area. The territory occupancy was judged stable if territorial calls were heard on at least two visits with more than 30 days in between. I used in this study only the data collected from March to May, the months of greatest singing activity of the species in the study area (fig. 2). In order to minimize the meteorological influences on the song production, I have used in the analysis only the nights without precipitation or strong wind.

Only the Tengmalm's males (11) with at least six listening nights, and with at least two singing nights in different months were considered.

The diurnal hearings have allowed to listen to diurnal song emission for seven of the males of Tengmalm's Owl, and only two of them have permitted to have data relative to more than one day (two days). I have judged as diurnal song the singing activity included from half an hour past sun rise to half an hour before sunset.

In order to evaluate the influence of the habitat characteristics on the Tengmalm's Owl's song, I recorded the altitude of the centre of the core area (ALT), and I measured the percent cover of some forest typologies inside a circular plot 1 km² wide, centred in the core area of every male (tab. I). The plot size was taken proportional to the Nearest Neighbour Distance (NND, NEWTON et al. 1977; DIETRICH & ELLENBERG 1982) of 1.0 (ES 0.04) km observed in the study area (BORGO 2013). I considered only the forestal typologies occurring in at least one third of the 11 sample squares: Piceo-fagetum, sub-alpine spruce forest, and mountain beech forest. The social variables considered were the distance of the core area of every Tengmalm's Owl male from the nearest core area of a conspecific male (NND), and from the nearest core area of a Tawny Owl male (NNDTO) (tab. I).

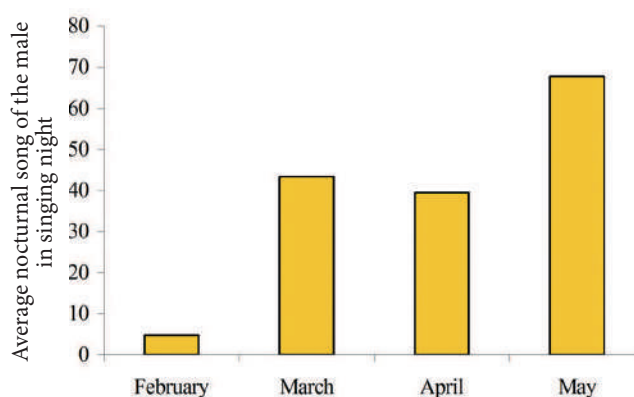


Fig. 2 - Monthly trend of the average nocturnal song (NS) emitted by males of Tengmalm's Owl (N=18) in the study area.

- *Andamento mensile della quantità media di canto notturno (NS) emesso dai maschi di civetta capogrosso (N=18) nell'area di studio.*

For each male the average nocturnal song (NS) was calculated, as the ratio of the total time (in minutes) of recorded nocturnal song (TNS) over the number of recorded singing nights (SN) of the male. Similarly, the average diurnal song (DS) was calculated as the ratio of the total time (in minutes) of recorded diurnal song (TDS) over the number of recorded singing days (SD) of the male. Then, for each male I calculated the percent of song emitted during daytime (%DS) as ratio of DS over the total average recorded song (NS+DS). The frequency of nights with vocal activity (SN/LN) was calculated as the ratio of the number of singing nights (SN) of the male over the total number of listening nights (LN) of the male.

Pearson correlations were employed to examine the relationship between the average nocturnal and diurnal song and the percent of diurnal song, and each environmental variable. A Multiple Regression Analysis (MRA) with stepwise procedure was employed to examine the relationship between the average nocturnal song and the environmental variables. All statistics are carried out using the software R-3.2.3 (<http://cran.r-project.org>).

Results

The territorial singing activity of the Tengmalm's Owl males increased from February to May (fig. 2). In the period March-May, the average efficiency of the listening activity, calculated as the frequency of nights with vocal activity (SN/LN) was 0.60 (SE=0.07). The average duration of the nocturnal song of each male was 13.7 (SE 4.2) minutes for singing night (tab. 2). I recorded diurnal songs for 7 males (63.6%). The diurnal song was brief and infrequent, with an average duration of 2.0 (SE=0.2) minutes for day and singing male.

The nocturnal song (NS) of the Tengmalm's Owl males resulted positively correlated with the altitude of the core area ($r=0.810$, $p=0.003$), with the percent surface of the core area square covered by the Piceo-fagetum ($r=0.746$, $p=0.008$), and with the distance of the singer's core area from the nearest core area of a Tawny Owl male (NNDTO: $r=0.858$, $p=0.001$). On the

contrary, the nocturnal song didn't result related to the distance of the singer's core area from the nearest core area of a conspecific (NND: $r= -0.404$, $p=0.218$; tab. III, fig. 3). Therefore, the nocturnal song of the Tengmalm's Owl seems to decrease with the shortening of the distance from a Tawny Owl core area, and to increase with the altitude and the increasing of the Piceo-fagetum forest availability, but it didn't result depending on density.

The Multiple Regression Analysis carried out by stepwise procedure brought to a model which selects only the distance between the core areas of the two species (NNDTO), and which explained 73.6% of the variability of the nocturnal song (tab. IV).

The distance to the nearest conspecific male (NND) was not related to the average nocturnal song of the males, but the frequency of singing nights (SN/LN) resulted almost significantly related with NND ($r=-0.541$, $p=0.085$), increasing with the density of rivals.

M	NS (SE) (min)	N (min)	NN/NT (m)	DS	NND (m)	NNDTO	% Mountain beech forest	% Piceo-% fagetum	Sub-alpine spruce forest	ALT (m)
1	44.0 (13.5)	5	0.71	3.0	1280	3000	12	81	0	1550
2	20.0 (11.7)	4	0.80	0.0	2370	1100	24	6	0	1450
3	3.5 (1.4)	4	0.50	2.0	3000	530	87	0	0	1200
4	31.7 (4.9)	3	0.43	1.0	1290	2500	34	56	28	1550
5	1.5 (0.4)	2	0.25	2.0	2370	780	43	0	0	1300
6	11.0 (7.7)	3	0.75	1.5	780	1750	6	47	19	1400
7	4.0 (0.5)	3	0.75	2.5	780	1000	37	44	7	1300
8	1.3 (0.3)	3	0.38	0.0	4000	1500	19	0	0	1400
9	17.5 (1.2)	3	1.00	0.0	1370	2100	0	12	56	1550
10	12.5 (3.5)	3	0.50	0.0	2500	1600	13	0	0	1400
11	3.3 (1.2)	3	0.50	2.0	1640	430	75	0	0	1350

Tab. II - Characteristics of the singing activity of each male (M), and values of the environmental variables measured in the sample plots 1 km² wide centred on the core area of the males (N=11). See the Methods for the names in full of the variables.

- Caratteristiche dell'attività di canto di ogni maschio (M) e valori delle variabili ambientali misurate nelle aree campione da 1 km² centrate sulla core area dei maschi (N=11). Vedi Metodi per le definizioni estese delle variabili.

Variable	Correlation coefficient	Significance
% Mountain beech forest	-0.437	0.179
% Piceo-fagetum	0.746	0.008
% Spruce sub-alpine forest	0.242	0.474
Altitude of the core area	0.810	0.003
NND	-0.404	0.218
NNDTO	0.858	0.001

Tab. III - Relations between the average nocturnal song (NS) of Tengmalm's Owl and the environmental variables in the sample plots 1 km² wide centred on the core area of the males (N=11): Pearson's correlation coefficients and significance values.

- Correlazioni tra la quantità media di canto notturno (NS) della civetta capogrosso e le variabili ambientali misurate nelle aree campione da 1 km² centrate sulla core area dei maschi (N=11): coefficienti di correlazione di Pearson e significatività.

Variable	Regression coefficient (ES)b	Significance
NNDAL0.014 (0.003)	0.858	0.001
R ² = 0.736	F = 25.067	df = 1; 9
		p = 0.001

Tab. IV - Results of multiple regression analysis of the average nocturnal song (NS) of the Tengmalm's Owl male on environmental variables.

- Risultati dell'analisi di regressione multipla della quantità media di canto notturno (NS) della civetta capogrosso rispetto alle variabili ambientali.

Variable	Correlation coefficient	Significance
% Mountain beech forest	0.697	0.017
% Piceo-fagetum	-0.220	0.515
% Spruce sub-alpine forest	-0.354	0.286
Altitude of the core area	-0.756	0.007
NND	-0.065	0.849
NNDTO	-0.683	0.021

Tab V - Relations between the average percentage of diurnal song (%DS) of Tengmalm's Owl and the environmental variables in the sample plots 1 km² wide centred on the core area of the males (N=11): Pearson's correlation coefficients and significance values.

- Correlazioni tra percentuale media di canto diurno (NS) della civetta capogrosso e le variabili ambientali misurate nelle aree campione da 1 km² centrate sulla core area dei maschi (N=11): coefficienti di correlazione di Pearson e significatività delle correlazioni.

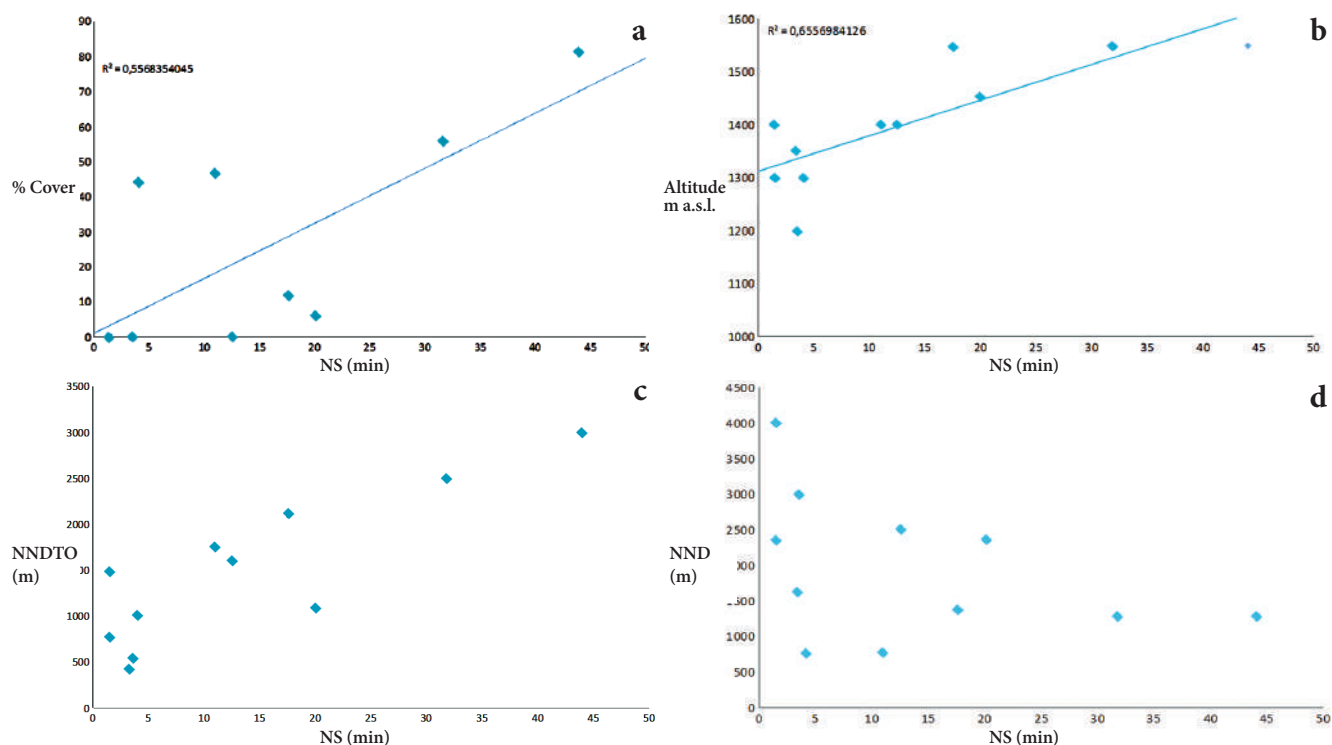


Fig. 3 - Relationship between the average nocturnal song (NS) of the Tengmalm's Owl and: a) the % cover of piceo-fagetum in the sample plots 1 km² wide centred on the core area; b) the altitude (m a.s.l.) of the core area; c) the distance of the male from the nearest core area of Tawny Owl (NNDTO); d) the distance of the singing male from the nearest core area of a conspecific male (NND).

- *Relazione tra la quantità media di canto notturno (NS) della civetta capogrosso e: a) la copertura % di piceo-fagetum nelle aree campione da 1 km² centrate sulla core area; b) la quota (m s.l.m) della core area; c) la distanza del maschio dalla più vicina core area di allocco (NNDTO); d) la distanza del maschio dalla più vicina core area di un maschio conspecifico (NND).*

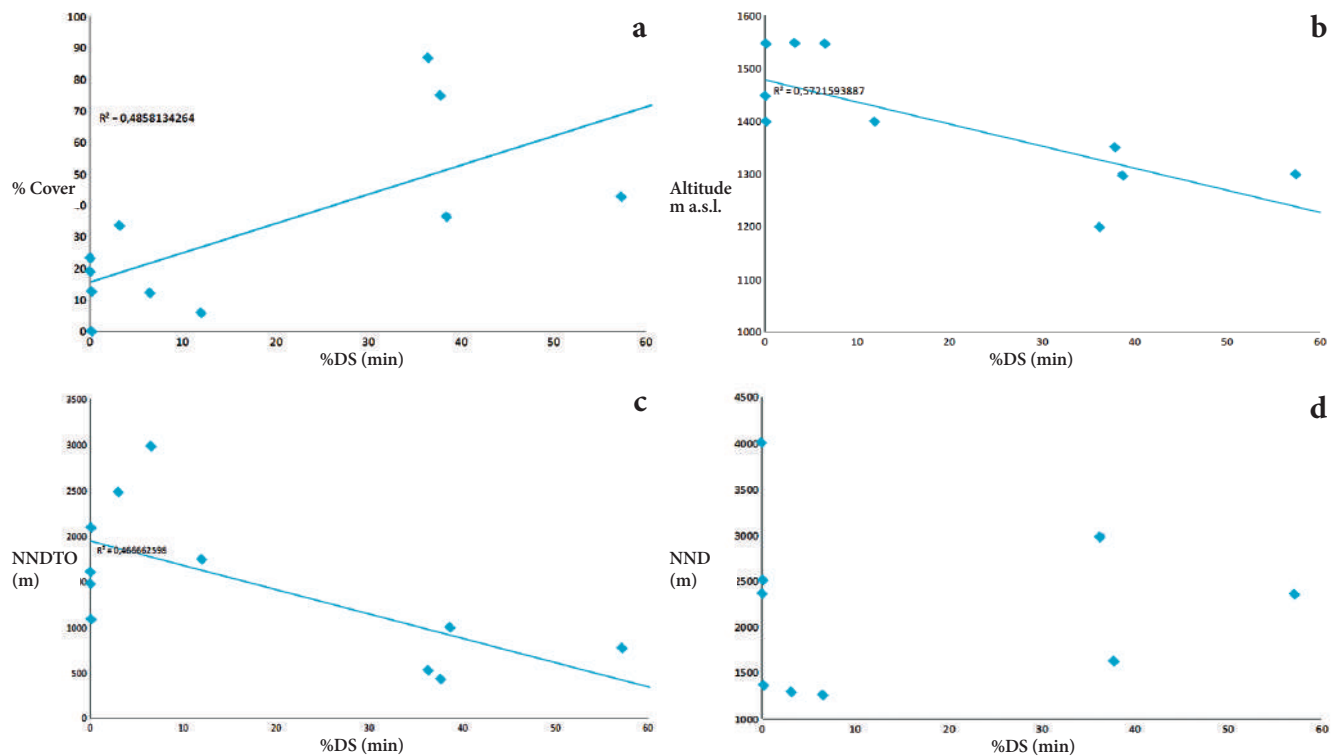


Fig. 4 - Relationship between the percentage of diurnal song (%DS) of the Tengmalm's Owl and: a) the %cover of mountain beech forest in the sample plots 1 km² wide centred on the core area; b) the altitude (m a.s.l.) of the core area; c) the distance of the male from the nearest core area of Tawny Owl (NNDTO); d) the distance of the male from the nearest core area of a conspecific male (NND).

- *Relazione tra la percentuale di canto diurno (NS) della civetta capogrosso e: a) la copertura % di faggeta montana nelle aree campione da 1 km² centrate sulla core area; b) la quota (m s.l.m) della core area; c) la distanza del maschio dalla più vicina core area di allocco (NNDTO); d) la distanza del maschio dalla più vicina core area di un maschio conspecifico (NND).*

The percentage of the song emitted by Tengmalm's Owl males during daytime (%DS) increased (tab. V; fig. 5) with the lowering of the altitude ($r=-0.756$, $p=0.007$), with the increasing of the mountain beech forest availability ($r=0.697$, $p=0.017$), and with the shortening of the distance from the nearest Tawny Owl core area ($r=-0.683$, $p=0.021$). In average, the males exhibiting diurnal vocal activity settled closer (1427 m, SE=382) to the nearest Tawny Owl than males without diurnal singing activity (1575 m, SE=206), but the difference was not statistically significant. The percentage of diurnal song increased inversely respect to the nocturnal song, but the correlation was not quite significant ($r=-0.558$, $p=0.075$). The percentage of diurnal song was not related with the distance from the nearest conspecific ($r=-0.065$, $p=0.849$), and therefore it didn't seem depending on population density.

The distances among the core areas of the males of Tengmalm's Owl (NND) was correlated with the availability of the Piceo-fagetum ($r=-0.685$, $p=0.020$) in the core area, but was not significantly related to the altitude ($r=-0.334$, $p=0.315$). Density resulted therefore to increase with the availability of selected habitat, more than directly with the altitude.

On the contrary, the distance between the core areas of Tengmalm's Owl and Tawny Owl (NNDTO) increased with the altitude ($r=0.867$, $p=0.001$), and with the availability of Piceo-fagetum forest ($r=0.742$, $p=0.009$), and decreased with the increasing of the mountain beech forest availability ($r=-0.714$, $p=0.014$).

The availability of the mountain beech forest in the core areas significantly increased with the altitude lowering ($r=-0.729$, $p=0.011$), whereas the availability of the Piceo-fagetum ($r=0.513$, $p=0.107$) and of the sub-alpine spruce forest ($r=0.552$, $p=0.079$) increased with the altitude not significantly.

Discussion

Tengmalm's Owl resulted to be victim of intraguild predation by Ural Owl *Strix uralensis* (HAKKARAINEN & KORPIMÄKI 1996) and Tawny Owl (BAUDVIN et al. 1995). Following SERGIO & HIRALDO (2008), Tawny Owl is a potential intraguild predator for Tengmalm's Owl because more than two times heavier. We never recorded predation events in the study area, but in two cases I observed a Tawny Owl fly close to a singing Tengmalm Owl, which answered by stopping his song and escaping, moving away and, later in the night, restart a brief song at higher altitude along the slope. Studies about habitat preferences carried out in the study area (BORGO 1999) evidenced that Tawny Owl and Tengmalm's Owl meet and overlap in a few forestal habitats of the mountain horizon. In this situation, the two species can be in competition for nest cavities and food (BAUDVIN et al. 1995).

In the study area, the Tengmalm's Owl presented some clear habitat preferences (BORGO 1997, 1999, 2011). The study of the habitat selection of the Tengmalm's Owl in the study area (BORGO 1999), carried out by analysis of utilisation-availability data with simultaneous Bonferroni confidence intervals (NEU et al. 1974; BYERS et al. 1984; ALLDREDGE & RATTI 1986), showed the selection of the sub-alpine spruce forest, the Piceo-fagetum forest and the mountain beech forest (BORGO 1999). The Tawny Owl on the contrary, according to its greater thermophily, selected the sub-mountain beech forest, and used the *Orno-Ostrietum* and the mountain beech forest in proportion to their availability, avoiding the *Piceo-fagetum* (BORGO 1997, 1999). The mountain beech forest is therefore the habitat (fig. 4) in which the niche overlap and the spatial overlap between the two species are greater. In accordance with this analysis, the results point out that the distance between the core areas of Tengmalm's Owl and Tawny Owl decreased with the increasing of the amount of mountain beech forest.

The analysis on the availability of the three habitats selected by Tengmalm's Owl showed that the abundance of Piceo-fagetum and sub-alpine spruce forest didn't result significantly correlated with the altitude. On the contrary, the abundance of the mountain beech forest increased with the altitude lowering. On the whole therefore, we observe that in the sample plots the availability of selected habitat is not correlated with the altitude.

The average nocturnal song of the Tengmalm's Owl males (NS) resulted increasing with the *Piceo-fagetum* abundance in the core area, with the altitude, and with the increasing of the distance of the core area of the singer from those of the nearest Tawny Owl. Considering the selection of the Piceo-fagetum evidenced in the study area (BORGO 1999), the relation between the abundance of this habitat and the quantity of song emitted by the Tengmalm's Owl male could be explained with the positive influence of the habitat quality on the song of the male, as noticed in others species (SEARCY 1979; GREIG-SMITH 1983; DAVIES & LUNDBERG, 1984; GOTTLANDER 1987; REID 1987; STRAIN & MUMME 1988; GARSON & HUNTER 1979; HIGGINS 1979; KROODSMA 1982; MORTON 1986; SANTEE & BAKKEN 1987). On the contrary, Tawny Owl tend to avoid this habitat in the study area, explaining why the distance between core areas of Tengmalm's Owl and Tawny Owl increase with the increasing of the Piceo-fagetum. These evidences suggest that the suitability, quality and selection of the piceo-fagetum by Tengmalm's Owl could be partly due to the lower risk of intraguild predation. The increase of the vocal emission of territorial males could therefore indicate to females the territory quality as regard both food resources and low risk of intraguild predation.

The correlation between song and altitude doesn't seem to be explainable simply by an increment of the

availability of habitats preferred by Tengmalm's Owl, because only one of them, the mountain beech forest, is significantly related with altitude. Considering that the nearest distance between the core areas of Tengmalm's Owl and Tawny Owl increased with the altitude, the increment of the vocal activity with the altitude seems to depend above all to an increase of the distance of the singer to its intraguild killer. Data suggest therefore that the increasing of the nocturnal vocal activity of the Tengmalm's Owl with altitude, probably reflects an increment of the habitat suitability due, at least in part, to the reduction of the risk of intraguild predation.

The Multiple Regression Analysis selected the distance from the nearest Tawny Owl as the most important factor in conditioning the nocturnal song of the Tengmalm's Owl males. The importance of this factor is stressed by the high percentage (73.6%) of the explained variability of the song of the species.

The increasing of the risk to be predated by Tawny Owl seems therefore to cause an increase in the costs of the song activity, and to explain the reduction of the song activity in Tengmalm's Owl with the lowering of the altitude. It seems possible that Tengmalm's owls become especially locatable and therefore vulnerable to the attacks of the intraguild killer during the singing activity. This vulnerability seems to influence the behavior of the Tengmalm's Owl males, affecting their song. A depression of the singing activity in relation to

the risk to be predated by a competitor is reported also in other owls communities (OLSON et al. 2005; CROZIER et al. 2006; ZUBEROGOITIA et al. 2007), and represents a short-term behavioural strategy to reduce the risk of predation, allowing the coexistence of intraguild prey and its killer (SERGIO & HIRALDO 2008).

The density of conspecific rivals, described by the distance of the singer from the nearest core area of another Tengmalm's Owl male, didn't seem to influence the vocal activity. It seems possible however, that the conspecific density might influence the frequency of vocal activity, with a decrease of the frequency of silent nights. Though the correlation was not significant ($p=0.08$), this result is in accordance with the positive effect of the density on the vocal activity noticed in other owl species (PENTERIANI 2003). This result suggests that in the areas of sympatry with Tawny Owl the song of the Tengmalm's Owl is affected more by the inter-specific than by the intra-specific competition. This fact also suggests that the risk to be predated is really high.

Though the diminution of the song rate could permit to the males living near the tawny owls a reduction in the risk of aggression, it likely restricts their possibility of intraspecific communication, imposing a reduction in the capacity of mate attraction and in the efficiency of repulsion of the competing males. The interspecific interference between the two intraguild species seems therefore to strongly affect the song of the smaller



Fig. 4 - Veduta autunnale della sinistra idrografica della Val Zemola (Erto e Casso), habitat elettivo della civetta capogrosso.
- Autumn view of the left bank of the Val Zemola (Erto and Casso), habitat of the Tengmalm's Owl.

species, interfering with its intraspecific relations. The depression of the song could reflect the dangerousness of the territory of the singing male, and besides it could represent a useful indicator of the low territory quality in the eyes of the females searching for a partner.

Considering that the dangerousness of a territory is an important component of its quality, the results of the study accord with the positive influence of the habitat quality on the song of the male, as noticed in others species (SEARCY 1979; GREIG-SMITH 1983; DAVIES & LUNDBERG 1984; GOTTLANDER 1987; REID 1987; STRAIN & MUMME 1988; GARSON & HUNTER 1979; HIGGINS 1979; KROODSMA 1982; MORTON 1986; SANTEE & BAKKEN 1987).

The percent of vocalisations emitted during daylight increased with the altitude lowering, contrarily to the nocturnal song that increased with the altitude, and with the related increase of the mountain beech availability. If we consider that diurnal and nocturnal song have the same function for the intraspecific communication, we could expect that diurnal and nocturnal song rates should be directly related. In this case a similar relationship with environmental factors should be expected. The inverse relation between nocturnal and diurnal singing activity, and their opposite relationship with the altitude, suggest that a factor altitude-related affect the song by day and by night differently. The variables related to the altitude resulted to be the availability of the mountain beech forest, a habitat selected by Tengmalm's Owl but used by Tawny Owls too (BORGIO 1997, 1999), and the distance of the Tengmalm's male to the nearest Tawny Owl territory. The suitable habitat availability is constant between diurnal and nocturnal period and it would be

expected to influence in the same way the song amount of a male by day and by night. I think therefore that the factor altitude-related differently affecting the song activity was the distance of the territorial males from their intraguild killer. Tawny Owl is in fact a strictly nocturnal predator that can locate Tengmalm's Owl singers only by night. The increasing of the diurnal song with the shortening of the distance from a Tawny Owl suggests that the Tengmalm's Owl males settled closer to Tawny Owls, and then more exposed to the risk to be located and predated by night, could increase their diurnal singing activity in order to compensate the lacking of nocturnal intraspecific communication. The diurnal singing activity of the Tengmalm's Owl males is infrequent and scarce (tab. I), but the results of this study suggest that it could play a significant role in intraspecific communication. A brief diurnal song could in fact contribute to the intraspecific communications (i.e. territory defence and mate attraction), without exposing the singer to the risk to be predated by Tawny Owl. This strategy could allow the male to maximise its fitness by reducing the costs of the song, and to increment the efficacy of the communication efforts.

The study supplies an evidence of the effects of the competition of the bigger Tawny Owl on the smaller Tengmalm's Owl. This competition is known in other regions of the range of the species (MIKKOLA 1983; BAUDVIN et al. 1995), or in different species of owls (OLSON et al. 2005; CROZIER et al. 2006). In particular, the results point out a behavioural strategy in vocal activity to reduce the risk to be predated by their intraguild killer species, according with the results obtained in other species as Little Owl (ZUBEROGOITIA et al. 2007) or Spotted Owls (OLSON et al. 2005; CROZIER et al. 2006).

The Tengmalm's Owl is a species listed in the Annex 1 of the 147/2009 European Directive, and the intraguild pressure of the Tawny Owl could become a factor affecting its conservation status in the Sites of Community Importance (SCIs) and Special Protection Areas (SPAs) composing the Nature 2000 network for the biodiversity preservation in Europe. The effects of this pressure could be stronger in the sites where, because of their low altitude, the mountain beech forest is the main habitat for Tengmalm's Owl settlement. In a global warming context, it seems possible that Tawny Owl could moreover expand its range, with an increasing of the negative impact on the conservation status of the Tengmalm's Owl. A long term monitoring of the distribution and density of nocturnal raptors carried out in the Dolomiti Friulane Natural Park, gave first evidence of the expansion of the distribution of the Tawny Owl in areas previously inhabited only by Tengmalm's Owl (A. Borgo, ined.). The effects of an increment of spatial overlap between the two species could involve a risk for the conservation of Tengmalm's Owl in the external (pre-alpine) portions of the Alpine chain, causing a contraction in the range



Fig. 5 - A specimen of Tengmalm's Owl appearing at its nesting hole digged by Black Woodpecker (*Driocopus martius*) in a beech (Photo by A. Borgo).

- Un individuo di civetta capogrosso si affaccia all'apertura della cavità di nidificazione scavata da picchio nero (*Driocopus martius*) in un faggio (Foto di A. Borgo).

of the species and its disappearance from many Sites of the Natura 2000 network.

The Tengmalm's Owl status is often surveyed as species of European concern, as component and indicator of the biodiversity status, and because sensible to the quality of the forest management and policy. In particular, the species density and distribution should be monitored to verify the presence or absence of significant effects of a forest exploitation, according with the prescriptions of the Habitat directive 43/92/CE.

The results of the study suggest that some particular attention should be taken in order to obtain reliable data on species distribution and abundance by surveying singing males occurrence. In fact, the singing rate of the species, and therefore its detectability, is not homogeneous in the territory, but is affected by the owl community and the risk of intraguild predation. This evidence must be strongly considered when the status of the species is surveyed, because the presence and abundance of Tengmalm's Owls on the lower part of its altitudinal range risk to be strongly underestimated. The results of the study suggest that the census effort should be altitude and habitat dependent, with a higher effort in sites or areas characterized by lower altitude and the dominance of mountain beech forest. In order to allow trend considerations, the census effort may be different across the study area, but obviously it must remain the same among all the repetitions carried out in successive years.

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