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Movements, activity patterns and home range of a female brown bear (*Ursus arctos, L.*) in the Rodopi Mountain Range, Greece

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ABSTRACT. Movements and activity patterns of an adult radio-tagged female brown bear accompanied by her cubs were documented for the first time in Rodopi area (NE Greece) from August 2000 to July 2002. Average daily movements were 2.45 ±2.26 SD km, (range 0.15-8.5 km). The longest daily range could be related to human disturbance (hunting activity).The longest seasonal distance (211 km), during summer 2001 coincided with the dissolution of the family. With cubs, the female was more active during daytime (73% of all radio-readings) than when solitary (28%). The female switched to a more crepuscular behaviour, after separation from the yearling (July 2001). According to pooled data from 924 activity - recording sessions, during the whole monitoring period, the female was almost twice as active during day time while rearing cubs (51% active) than when solitary (23%). The autumn and early winter home range size of the family was larger (280 km^2) than after the separation from the cubs (59 km^2). During the family group phase, home range size varied from 258 km^2 in autumn to 40 km^2 in winter (average denning period lasted 107 days : December 2000-March 2001). The bear hibernated in the Bulgarian part of the Rodopi Range during winters of 2001 and 2002.

KEY WORDS : *Ursus arctos*, brown bear, movements, activity patterns, home range, Rodopi, Greece.

INTRODUCTION

The brown bear (*Ursus arctos, L.*) distributional range in Greece comprises two distinct nuclei located in the Pindos Mountain Range (NW Greece) and the Rodopi Mountain Complex (NE Greece). The total area of continuous bear range comprises 8,600 sq.km, while re-colonization of former range appears in southern Pindos Mountains (Fig. 1). The minimum population has been estimated at 130-160 individuals (MERTZANIS, 1999). The minimum brown bear sub-population in Rodopi area is estimated up to 25-30 individuals (MERTZANIS, 1999), which is 19% of the total bear population in Greece. This sub-population is connected only with the southern Bulgarian bear sub-population (Bulgarian Rodopi).

The brown bear is a fully protected species in Greece under national and EU legislation. Since 1994 and until 2003 systematic monitoring programs for brown bear conservation purposes in Greece are conducted on a continuous basis by the NGO "Arcturos" in cooperation with the national competent authorities. Telemetry techniques to study bear behaviour and ecology were implemented for the first time in 1997. Until then monitoring data came from observation and compilation of bear activity signs. In Rodopi area, the first successful capture and radio-tagging of an adult female bear with her cubs occurred in summer (August) 2000.

This study was carried out from August 2000 to July 2002 within the framework of a "LIFE-Nature" project for the Conservation of the brown bear in Greece. The fragile status of brown bears in Europe and especially in the southern parts of the continent, as well as the lack of data on the ecology and behaviour of the animals in Greece, incited us to undertake this study. The present paper aims to document for the first time movements and activity patterns of a radio-tagged adult female brown bear accompanied by her cubs in the Rodopi area. This and similar results will contribute to the adjustment and orientation of conservation measures for the species.

MATERIAL AND METHODS

Study Area

The study area is located in NE Greece and comprises the medium and higher altitudes of the western and central Rodopi Mountain Complex (Fig. 1). The Mountain Complex is located between 41° 12' and 41° 36' N and 24° and 25° 06' E. The total surface is about 1,731 sq km. It is a vast granitic complex covered with large forests and located in the drainage of the Nestos River valley.

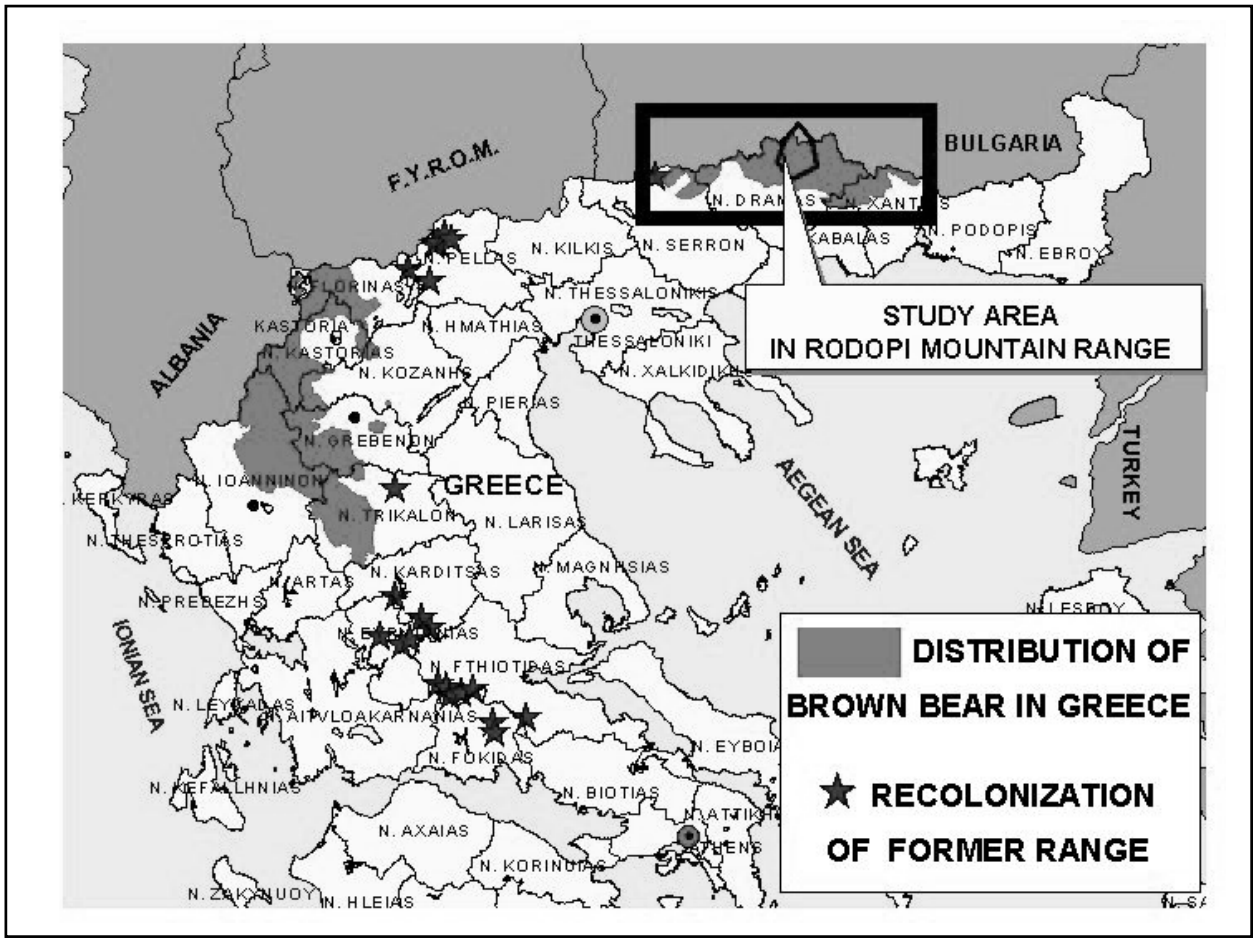

Fig. 1. – Location of the study area and brown bear range in Greece.

Continuous forest covers about 68% of the study area. Main forest types and percentage of coverage are : oak (*Quercus* sp.) (60%) at lower altitudes, beech (*Fagus* sp.) (20%), Spruce (*Picea excelsa*) (15%), Scots pine (*Pinus sylvestris*) (17.5%) and black pine (*Pinus nigra*) (3%). The terrain is generally rugged and is characterized by perennial, cold water streams and rivers. Elevations range from 500-2,232 m above sea level. Mean annual temperatures range from 27.1° C in summer to -4.7° C in winter. Mean annual precipitation is 980 mm. Nearly all native European mammal species are present in the area, including the wolf (*Canis lupus*), roe deer (*Capreolus capreolus*), chamois (*Rupicapra rupicapra*), wild cat (*Felis sylvestris*) and otter (*Lutra lutra*). The study area is remote, characterized by low human density and scattered human settlements. Abandoned villages have increased the diversity of bear food because of abundant orchards. A high density of forest road network related to timber activities reaches almost 15m/ha, and gives access to a relatively high level of hunting pressure. Hunting is allowed from August to January. Game reserves cover 6.16% of the core part of the study area.

Study Animals and Methods

An adult female brown bear, aged 8-10 years [age estimated *in situ* from dentition characteristics (JONKEL, 1993)], weighing approx. 120 kg and accompanied by two cubs of the year was captured with an 'Aldrich Foot Snare' trap on 4 August 2000 (at 20:30) after 64 trapping nights. The bait used was an active beehive. The bear was sedated with KHCl/xylazine (Rompun) (initial volume 750mg/3ml injected with blowpipe) and a booster volume of 750mg/3ml (with intra-muscular injection). Time to anaesthesia was less than 5 minutes. Total immobilization time was approx. 30min. The bear was fitted with a radio-collar ('Telonics MOD-500 NH') with bi-modal "activity-inactivity" signal. The antagonist used was "Yohimbine" (25 mg /ml). Radiolocations were taken on a daily basis using a TR-4 "Telonics" receiver, with a minimum of three bearings using the "raised antenna - null signal" (RA – NS) technique.

Data Processing and plotting was achieved using 'LOCATE' and GIS (ArcInfo, ArcView) software. Daily movements were calculated from consecutive day to day radiolocations, using ArcView program extension "Animal Movement Analysis" (Kenward, 2001). Geographic coordinates of the bearing points were obtained by GPS and were processed through LOCATE software for triangulation. Subsequently, the exported co-ordinates were used in several functions (as well as by the standard ArcView functions). The line coverage that was used was optimised with the "point to polyline" tool in the program.

Two approaches were used to evaluate activity levels. The first approach consisted of recording the activity status at each daily bearing and radio-location. In this case activity levels were examined over the whole dataset, which was separated into two different groups : the daylight hours, that is from 07:00-19:00, and the night hours, 19:00-07:00. The second approach was achieved through 24h monitoring sessions operated once every month. The bear's activity was recorded every half hour for 3-5 min of continuous listening. Activity status was deduced by measuring the time of the active and inactive signal modes. Mann-Whitney U Tests were used for statistical comparisons of results. Home Range estimation was based on the 'Minimum Convex Polygon' (MCP) method (MOHR 1947, HAYNE 1949).

RESULTS

Between August 2000 and December 2001, daily movements of the bear family were defined with 924 bearings, which yielded 365 radiolocations that were plotted, averaging one location /1.3 days. Average straight-line distance between successive daily radiolocations of the bear averaged 2.45 km (± 2.26 SD). Of all daily movements 65% were less than 2.45 km. The shortest distance was 0.15 km whereas the longest daily distance was 8.5 km and occurred in early autumn (September) 2000. In both autumn 2000 and 2001 (mid September to end of November) daily distances travelled in weekends were significantly higher than those travelled during weekdays (Mann-Whitney U-Test : autumn 2000 : $p<0.05$; autumn 2001 : $p<0.05$,).

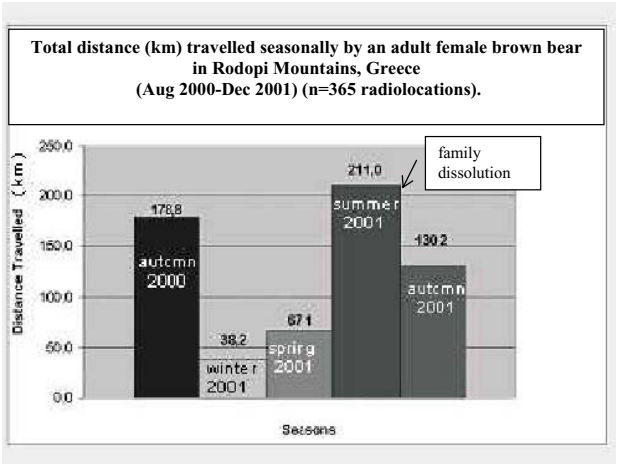

Fig. 2. – Seasonal mouvements of the brown bear family inthe Rodopi Mountains, from August 2000 to December 2001.

For the same monitoring period and at a seasonal scale, total seasonal movements of the bear family and the lone female showed also characteristic variations (Fig. 2). The highest values were obtained in three periods : mid June to mid September 2001, time of the family dissolution, autumn 2000, bear with cubs, and mid September to end of November 2001, when the bear was solitary without yearling with 211, 178.8 and 130.2 km travelled respectively.

Another shift in the female bear's activity pattern occurred after separation from her cub(s). The female bear was significantly more active during the daylight hours when the family group was still together (Mann-Whitney U-Test, $p<0.05$,). This pattern was confirmed by comparing the overall activity frequencies (924 bearings) between day (from 07:00 to 19:00) and night (from 19:00 to 07:00) hours (Fig. 3). The activity of the female during daylight fell from 52.1% while with her cubs, to 23.1% after having separated from her cubs in July 2001. On 12 July 2001 a short visual contact with the bear family confirmed the presence of one cub.

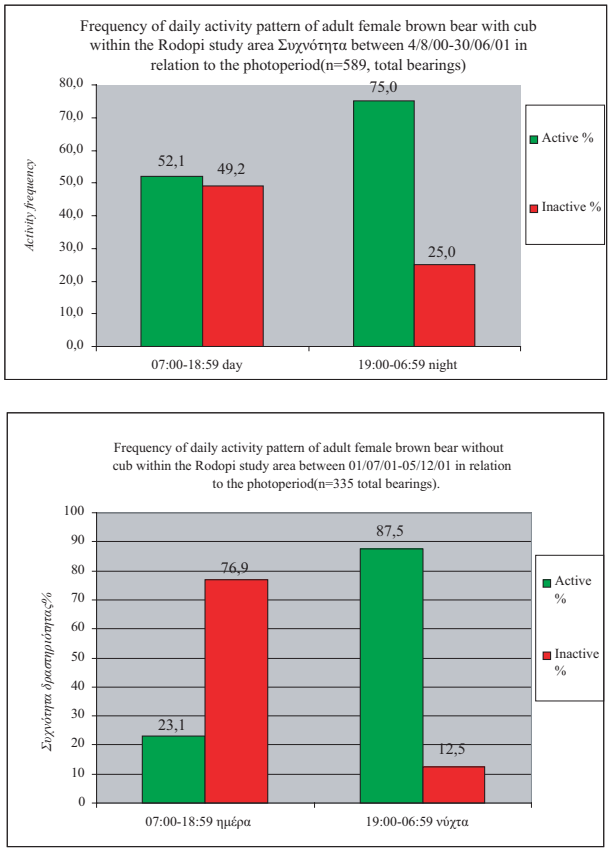

Fig. 3. – Female brown bear activity patterns with and without cubs in the Rodopi Mountains, Greece, as shown by daily locations (n=924).

Diel activity of the female during the two periods with and without cub(s), was also recorded. While with her cub(s) the female showed more continuous periods of activity throughout the day, and especially during daytime. In this case the 24h cycle was interrupted by relatively short intervals of inactivity (Fig. 4). After separation from her cub(s) the 24h activity pattern became much longer with clearly continuous intervals of inactivity during the day, from 10:00 to 17:00, and clear bouts of activity during the night, between 19:00 and 03:00 (Fig. 4).

Winter inactivity of the female bear during two denning periods averaged 107 days and concerned the same denning site that was used repeatedly for two consecutive winters (2000 and 2001). The site was located on Bulgarian territory in the Rodopi Mountain Range, in a small and steep canyon covered by spruce (*Picea excelsa*) forest. This small valley had a northern exposure and was characterized by harsh winter conditions. The den was dug under a rock, and the entrance was camouflaged with spruce branches.

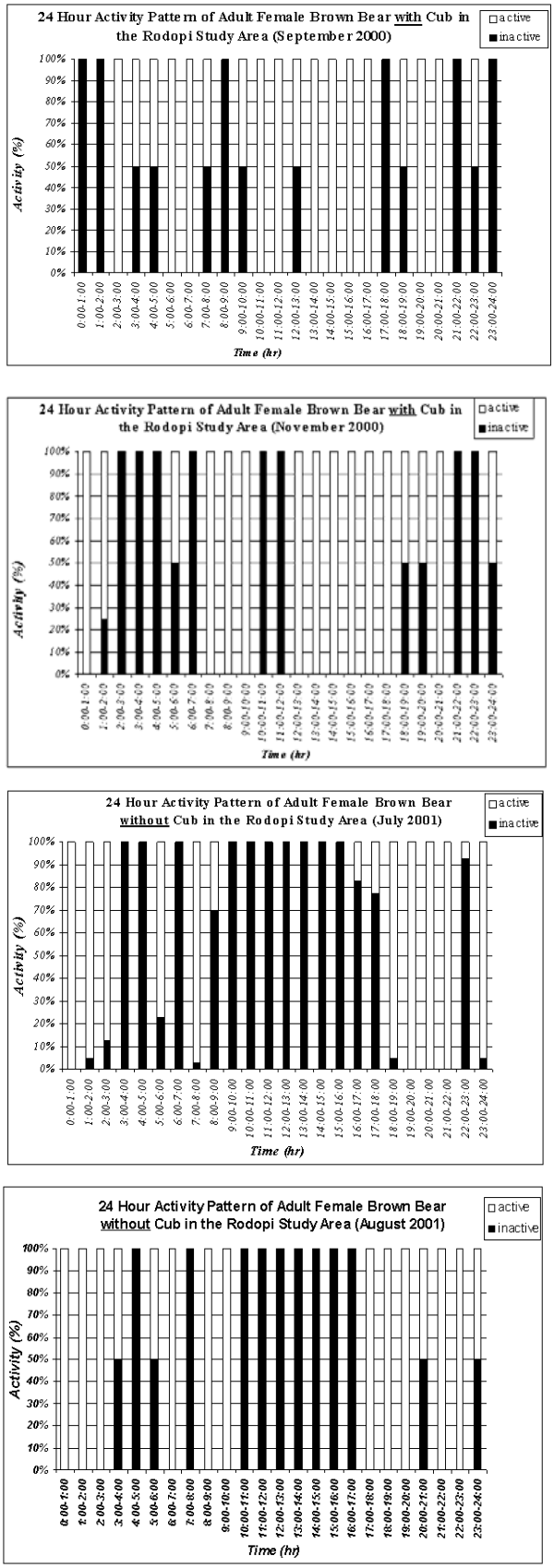

Fig. 4. – Female brown bear diel activity patterns with and without cubs as shown by 24h monitoring sessions in autumn 2000 and summer 2001.

Data on home range area also showed notable variation most likely related to the separation of the female from her cub(s). The most marked difference occurred from mid September to end of November declining from 349 sq. km in 2000 (female with cubs) to 107.5 sq. km in 2001 (solitary female). This can be associated with the overall decrease of the home range area, which was 280 sq km in mid September to mid December 2000 when the family was intact, to 59 sq km at the same period in 2001 when the female was solitary (Fig. 5). In addition the smallest home range area was recorded during the winter, from mid December to early March and measured 40 sq km, at the pre-denning period. In contrast, the largest home range area was recorded during the period from mid September to end of November, and measured 280 sq km, when the family group was together. In general, seasonal variations of home range area appeared to follow and correspond to the seasonal variations of movements.

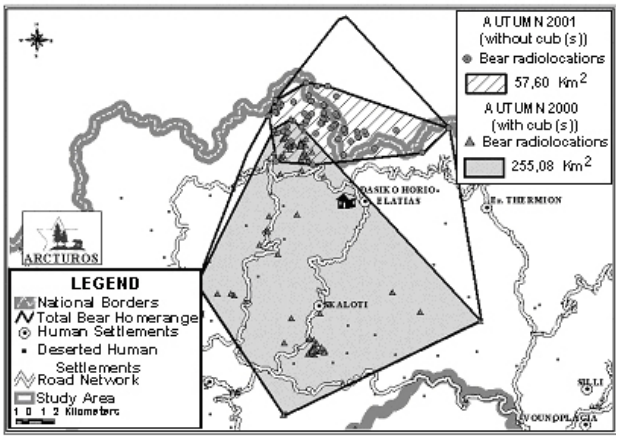

Fig. 5. – Female brown bear home range areas in autumn 2000 (with cubs) and autumn 2001 (without cubs).

DISCUSSION

In terms of daily movements, the female bear covered distances more or less similar to bears in other European countries, such as those for male and female bears in Croatia (HUBER & ROTH, 1986 ; 1993) and for a male bear in Spain (CLEVENGER et al., 1990). On the other hand, the significant differences of the bear family's daily movements in autumn 2000 and notably during weekends could be related to the high hunting pressure occurring in the study area in weekends. Many hunters were present during the weekends, they were organized into groups, used base camps within the forest as headquarters and conducted drive-hunts as the main hunting practice for wild boars (*Sus scrofa*). This was a major factor of disturbance probably causing the bear family to move continuously to avoid humans. Drive-hunts have been also identified as a serious human caused mortality factor for bears in the study area (MERTZANIS, 1994).

Field observations, corroborating telemetry data, confirmed that displacement of the bear family from undisturbed sectors (with continuous presence and activity during the week), coincided with hunting activity occurring in the same sectors during the weekends. Similar avoidance movements in response to human activities, such as

recreation, have also been recorded for a bear family in the Cantabrian Mountains in Spain (NAVES et al., 2001).

On the other hand, the long distances travelled by the family (176.8 km) as well as the high home range values (255.08 sq km) in autumn 2000 might further be related to educational processes of the female towards the cub(s). This process includes learning of locations with available and suitable food resources, safe shelter as well as avoidance of human disturbance. In contrast, the relatively long distances (130.2 km) travelled by the solitary female in autumn 2001, within a comparatively smaller home range (57.6 sq km), could be related to avoidance behaviour of the mother towards her yearling(s). This happened after the dissolution of the family, which is assumed to have occurred in late July 2001.

As far as dial activity is concerned, the patterns found in Rodopi are very similar to the ones observed for five males and one female adult bear in Pindos Mountain Range, Greece (MERTZANIS et al., 2003), as well as for solitary bears in Italy (ROTH, 1983), Croatia (ROTH & HUBER, 1986) and Spain (CLEVENGER et al., 1990). On the other hand, the differences in diel patterns observed between the solitary and family phases of the same female bear and more particularly, the increased level of activity during daylight hours for the bear accompanied by the yearling(s) could be associated with an increased nutritional need due to lactation, the education of the yearling and its familiarisation with the surrounding habitat, as well as with the avoidance of infanticidal males that kill cubs (SWENSON et al., 2001).

Lastly, results concerning the home range areas of solitary females are very similar to those recorded for solitary animals in Croatia (HUBER & ROTH, 1993). Larger home ranges for the family could be related to greater nutritional needs not only of the female but also for the cubs in search for suitable and patchy food sources.

The combination of the results of the present study with previous systematic surveys enhances considerably the proposed delineation of important bear habitat units in the study area. These results have been incorporated in the final zoning proposals for the creation of a National Park in the Rodopi area, as processed by "Arcturos" NGO and in cooperation with national competent authorities, under the National Environment Law 1650/86. In addition, the above results confirmed the ecological importance of the "NATURA" 2000 (pSCI) site "Elatia" (GR1140003) located in the study area. Moreover, we hope that similar results will also contribute in the reorganisation of warden patrols during the hunting season in order to minimize disturbance related to hunting pressure, and a co-ordination of management actions engaged on a trans-border scale.

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