

## A Study on the Breeding Biology of Some Bat Species in Turkey (Mammalia: Chiroptera)

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**Abstract:** This study is based on the records of gestation and lactation periods of 17 bat species (*Rousettus aegyptiacus*, *Rhinolophus ferrumequinum*, *R. hipposideros*, *R. euryale*, *R. blasii*, *Myotis myotis*, *M. blythii*, *M. emarginatus*, *M. nattereri*, *M. mystacinus*, *M. capaccinii*, *Eptesicus serotinus*, *Pipistrellus pipistrellus*, *P. kuhlii*, *P. savii*, *Plecotus auritus*, and *Miniopterus schreibersii*) caught from various localities in Turkey and of the development stages of embryos belonging to *Myotis* species. It was determined that the gestation period of some insectivorous bat species was generally May and June and following this period the lactation period was June and July in Turkey. In the fruit bat, *Rousettus aegyptiacus*, the gestation and lactation periods were May, July, August and September.

**Key Words:** Embryo, Pteropodidae, Rhinolophidae, Vespertilionidae, Turkey

### Türkiye'deki Bazı Yarasa Türlerinin Üreme Biyolojisi Üzerine Bir Araştırma (Mammalia: Chiroptera)

**Özet:** Bu araştırma Türkiye'deki çeşitli lokalitelerden alınan 17 yarasa türünün (*Rousettus aegyptiacus*, *Rhinolophus ferrumequinum*, *R. hipposideros*, *R. euryale*, *R. blasii*, *Myotis myotis*, *M. blythii*, *M. emarginatus*, *M. nattereri*, *M. mystacinus*, *M. capaccinii*, *Eptesicus serotinus*, *Pipistrellus pipistrellus*, *P. kuhlii*, *P. savii*, *Plecotus auritus*, *Miniopterus schreibersii*) gebelik ve emzikli dönemleri ile bazı türlere ait embriyoların gelişim safhalarının kaydına dayanmaktadır. Bazı böcekçil yarasa türlerinin gebelik dönemleri genellikle Mayıs ve Haziran arasında ve bu dönemi takiben emzikli dönemleri Haziran ve Temmuz'da saptanmıştır. Meyve yarasası, *Rousettus aegyptiacus*' da, gebelik ve doğum dönemleri Mayıs, Temmuz, Ağustos ve Eylül'de kaydedilmiştir.

**Anahtar Sözcükler:** Embriyo, Pteropodidae, Rhinolophidae, Vespertilionidae, Türkiye

### Introduction

Neonates of placental mammals were divided into 2 groups as altricial (ears and eyes are closed at birth) and precocial (ears and eyes are opened at birth). Insectivores, rodents and carnivores generally possessed altricial neonates, whereas artiodactyls, perissodactyls, cetaceans and primates possessed precocial neonates (Martin and Maclarnon, 1985). A few bat species were recorded as precocial and some of them as altricial, while most of them were classified as intermediate (Kurta and Kunz, 1987). The young of Vespertilionidae were hairless while those of Rhinolophidae had sparse hair at birth (Corbet and Southern, 1977).

Corbet and Southern (1977) stated that spermatogenesis and copulation in bats were recorded in summer and autumn, respectively, in Britain. In addition,

females and males, storing sperm in winter, could sometimes copulate in spring. Thus ovulation and fertilisation were recorded in April and May. Although the gestation period was approximately 50 days in bats, foetal development could be slowed in bad weather conditions, and thus gestation period might show variation. Cumming and Bernard (1997), Christie et al., (2000), and Lariviere and Ferguson (2003) reported that as the mammal species distributed at high latitudes of the Palaearctic Region gave birth in spring, those distributed in the temperate zone gave birth earlier than spring. In Africa, species belonging to Pteropodidae, Rhinolophidae and Vespertilionidae gave birth in October, November and December.

The aim of this study was to give some information about gestation, lactation periods and development stages of embryos of some bat species in Turkey.

## Materials and Methods

This study was based on the macroscopic investigation of 78 adult females with 46 embryos captured during taxonomical and karyological research in Turkey between 1997 and 2004, along with 173 females with embryos and 58 juveniles captured by Prof. Dr. İ. Albayrak between 1975 and 1993 and deposited in his collection. Only the data recorded in the field records were used in this study. Weights of the pregnant females along with their embryos, removed and fixed in 10% formalin and nonpregnant females, were recorded and are given in Table 1. The collection numbers of the embryos were given by addition of the letter "E" to the maternal collection number. Numbers in parentheses indicate the record number of the specimens.

To determine the development stages of removed embryos of the genus *Myotis*, the definitions given by Adams (1992) were used. Embryos were examined under a binocular microscope. Depending on the definitions by Adams (1992), stages were numbered from 1 to 7 according to some diagnostic features seen in the embryos: "Stage 1: Four limbs and a tail buds are present. The tail bud is slightly longer than the hind limb buds. Stage 2: Forelimb buds are still buds in shape but the hand regions are pronounced and the tail bud is twice longer than hind limb buds. Stage 3: Notched hand, foot plates, elbow and ankle joints are well pronounced. Stage 4: Pinnae, patagium between forelimbs, hindlimbs and tail, ankle joints, claws and rostrum are well pronounced. Stage 5: Pinnae, phalanges and pes are further elongated than stage 4 and vibrissae are present. Stage 6: Rostral region shows an increase, hair follicles are densely pronounced at face. Stage 7: Hair follicles are present on the entire body, the patagium is well developed, cranial sutures are less pronounced because of the fusion between major cranial bones and at this stage the embryo is said to be near parturition".

There was no criterion on the development stages of the families Pteropodidae, Rhinolophidae and Vespertilionidae except the genus *Myotis*; thus the development stages of embryos of these families were not included in this evaluation.

The specimens examined in this study are deposited at the University of Kırıkkale, Faculty of Science and Arts, Department of Biology.

## Results

Thirty-two bat species belonging to the families Pteropodidae, Emballonuridae, Rhinolophidae, Vespertilionidae and Molossidae are distributed in Turkey (Albayrak, 1990, 1993, 2003; Benda and Horáček, 1998; Sachanowicz et al., 1999).

In this study the gestation and lactation periods of 17 bat species belonging to the families Pteropodidae, Rhinolophidae and Vespertilionidae and some development stages of embryos of the genus *Myotis* were examined.

### Fam: Pteropodidae

#### *Rousettus aegyptiacus* (Geoffroy, 1810)

Ten specimens were examined from Mersin, Adana and Hatay. We encountered gravid females in May and July. No embryo was encountered in 2 individuals caught from Hatay and Mersin in April (Figure 1, Table 1).

### Fam: Rhinolophidae

#### *Rhinolophus ferrumequinum* (Schreber, 1774)

Twenty-nine specimens were examined from İzmir, Manisa, Muğla, Eskişehir, Ankara, Kırıkkale, Samsun, Adana, Hatay, Kahramanmaraş, and Erzincan. We encountered gravid females in April, May and June and lactating ones in May, June and July. No embryo was encountered in the individual caught from Erzincan in September (Figure 2, Table 1).

#### *Rhinolophus hipposideros* (Bechstein, 1800)

Specimens were examined from Kırklareli, Sinop, Samsun, Ordu, Trabzon, Rize, Artvin, Van and Adıyaman. We encountered pregnant females in June and July and lactating ones in July, August and October. Gravid and lactating females were recorded together in the same colony in July.

#### *Rhinolophus euryale* Blasius, 1853

The specimen caught from Antalya in April was not pregnant but an embryo was encountered in the specimen (2017) obtained from Burdur in May (Figure 2, Table 1). Specimens from Ordu and Adapazarı caught in June and July, respectively, were pregnant.



Figure 1. An embryo belonging to *Roussettus aegyptiacus* (E-1736).

Table 1. Weights (minimum, mean, maximum) of nonpregnant, pregnant females and embryos removed from the females and percentage of embryonal weight to the maternal weight (n = sample size).

Species	Nonpregnant female weight (g)	Pregnant female weight (g)	Embryonal weight (g)	Percentage of embryonal weight to maternal weight (%)
<i>Roussettus aegyptiacus</i>	86 (92.5) 99 (n = 2)	141 (n = 1)	13 (n = 1)	10.1
<i>Rhinolophus ferrumequinum</i>	24 (n = 1)	18.5 (19.8) 21.0 (n = 3)	0.08 (0.5) 1.1 (n = 3)	6.3
<i>R. euryale</i>	6 (n = 1)	11 (n = 1)	0.4 (n = 1)	3.7
<i>Myotis myotis</i>	20.0 (22.9) 27.0 (n = 10)	23.0 (30.9) 7.0 (n = 6)	1.3 (5.3) 7.5 (n = 6)	5.9-25.9
<i>M. blythii</i>	20.0 (21.2) 22.5 (n = 4)	21.0 (22.5) 24.0 (n = 4)	0.6 (0.7) 0.9 (n = 4)	2.9-4.2
<i>M. nattereri</i>	6.5 (7.0) 7.5 (n = 2)	6 (n = 3)	0.2 (0.4) 0.6 (n = 3)	3.4-11.1
<i>Eptesicus serotinus</i>	-	25.5 (n = 1)	4.5 (n = 1)	21.4
<i>Pipistrellus pipistrellus</i>	-	4.0 (4.5) 5.5 (n = 5)	0.05 (0.2) 0.5 (n = 8)	0.1-22.2
<i>P. kuhlii</i>	-	5.5 (6.1) 6.5 (n = 4)	0.2 (0.4) 0.8 (n = 8)	6.5-36.3
<i>P. savii</i>	-	7.5 (n = 1)	0.1 (n = 2)	2.7
<i>Miniopterus schreibersii</i>	9.0 (9.2) 9.5 (n = 2)	10.5 (12.3) 15.0 (n = 8)	0.07 (0.8) 2.0 (n = 8)	0.6-18.1

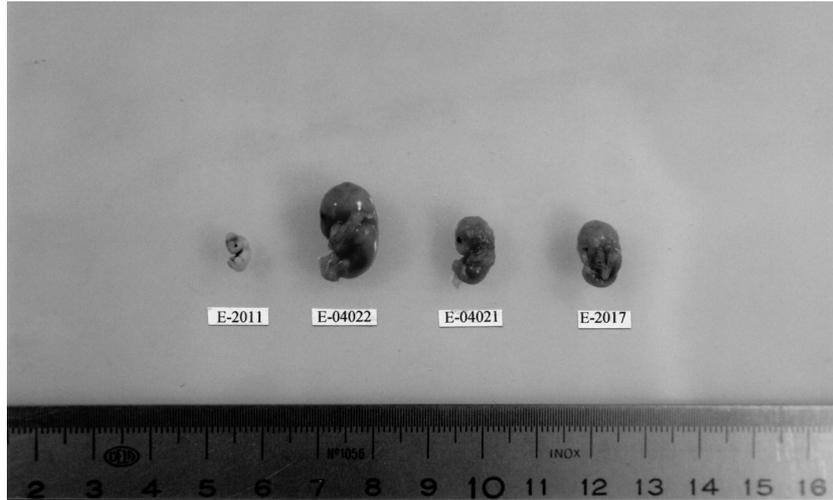


Figure 2. Embryos belonging to the genus *Rhinolophus*: *R. ferrumequinum* (E-2011, E-04022, E-04021); *R. euryale* (E-2017).

*Rhinolophus blasii* (Blasius, 1857)

No embryo was encountered in the individual caught from Kirklareli in August.

Fam: *Vespertilionidae*

*Myotis myotis* (Borkhausen, 1797)

We examined 29 specimens from Ankara, Tokat, Gümüşhane, Ordu, Niğde, Antalya, Hatay and Artvin. Five specimens (97002, 97003, 97008, 97011 and 97013) caught from Ankara in May and June were pregnant. Of these gravid females, 2 (97011 and 97013) gave birth in the laboratory. Two specimens caught from the same cave in June and a specimen from Hatay in April were not pregnant. Two specimens (98013 and 98015) caught from Ankara in May were pregnant and one of (98015) these gravid females gave birth in the laboratory. Of the 6 specimens caught from Artvin in June, only one (98023) was carrying a male newborn young with eyes were not opened and weighting 9 g. Two females carrying newborn young were also captured from the same cave and then released. Five specimens caught from Ankara and Antalya in April and July, respectively, were not pregnant. The embryos (E-97002, E-97003, E-97008, E-97013 and E-98013) were at stages 6 and 7 (Figure 3).

It was noted that *Myotis myotis*, widely distributed in Turkey, generally possessed embryos at stages 6 and 7 in

May and June. Lactating females were recorded in May, June and July.

*Myotis blythii* (Tomes, 1857)

An individual (97005) obtained from a cave in Ankara in May possessed an embryo at stage 5. Two specimens caught from Tokat and 1 from Antalya in April and June, respectively, were not pregnant. A specimen (2020) caught from the same cave in Tokat in June and 3 specimens (04023, 04024 and 04025) caught from Kırıkkale in May, had embryos at stages 4 and 5 (Figure 3, Table 1). A lactating female was caught from Erzincan in September.

*Myotis emarginatus* (E. Geoffroy, 1806)

Lactating females were encountered in Manisa and İzmir in June.

*Myotis nattereri* (Kuhl, 1818)

Of the 5 specimens caught from Hatay in May, 3 (1775, 1776 and 1782) were carrying embryos at stages 4 and 5 (Figure 3).

*Myotis mystacinus* (Kuhl, 1817)

Eleven specimens were examined from İzmir, Muş, Bitlis and Van. We recorded gravid females in July and lactating ones in June and July.

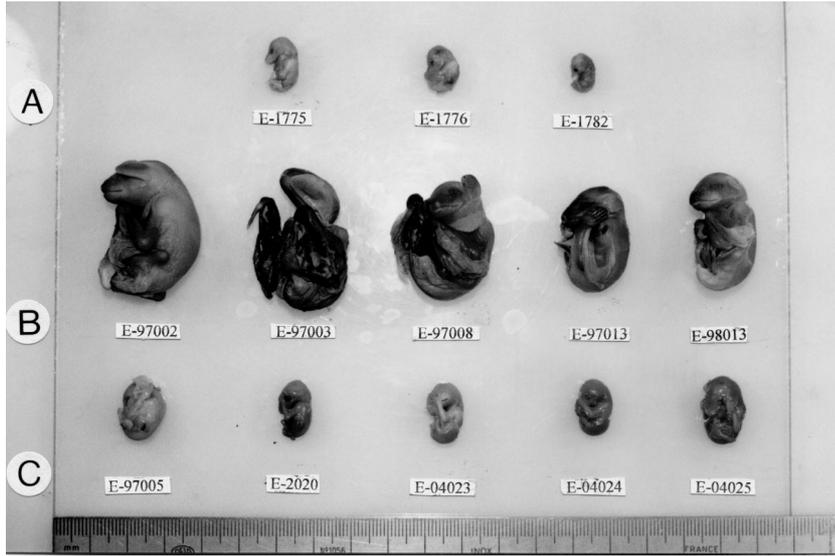


Figure 3. Embryos belonging to the genus *Myotis*: *M. nattereri* (A: E-1775, E-1776, E-1782); *M. myotis* (B: E-97002, E-97003, E-97008, E-97013, E-98013); *M. blythii* (C: E-97005, E-2020, E-04023, E-04024, E-04025).

*Myotis capaccinii* (Bonaparte, 1837)

Specimens obtained from Isparta and Kırklareli in May and August, respectively, were not pregnant.

*Eptesicus serotinus* (Schreber, 1774)

An embryo near parturition was encountered in a specimen (98017) caught in Ankara in June (Figure 4,

Table 1). Also 6 young specimens without their mothers were caught from Trabzon in June.

*Pipistrellus pipistrellus* (Schreber, 1774)

We encountered pregnant and lactating females from Manisa, Aydın, Muğla, Adana and Kahramanmaraş in May and June (Figure 4). Three specimens (98010, 1805,

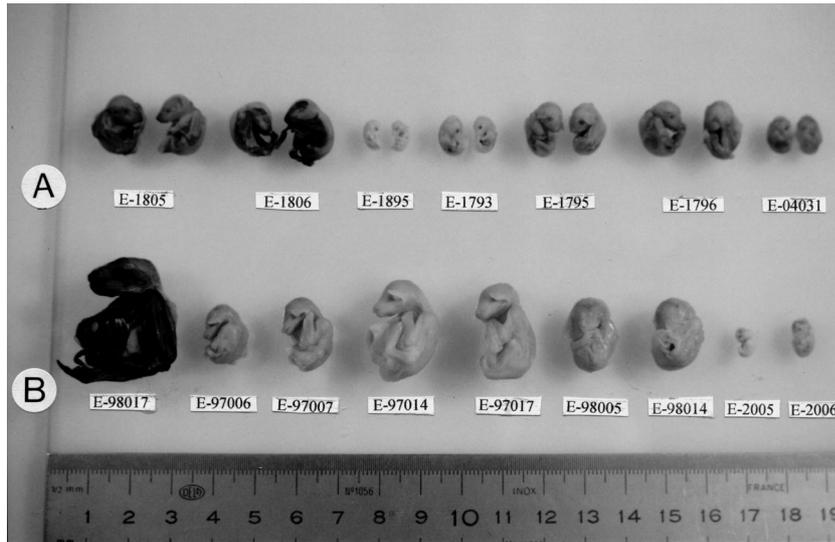


Figure 4. Embryos belonging to the genera *Pipistrellus*, *Eptesicus* and *Miniopterus*: *Pipistrellus pipistrellus* (A: E-1805, E-1806); *P. savii* (A: E-1895); *P. kuhlii* (A: E-1793, E-1795, E-1796, E-04031); *Eptesicus serotinus* (B: E-98017); *Miniopterus schreibersii* (B: E-97006, E-97007, E-97014, E-97017, E-98005, E-98014, E-2005, E-2006).

1806) were carrying twin embryos while 2 (98011, 98012) were carrying only 1 embryo in each.

*Pipistrellus kuhlii* (Kuhl, 1819)

We examined 36 specimens from Antalya, Hatay, Osmaniye and Kilis. Gravid females were encountered in May and June. Of the 2 gravid females caught in a colony from a cave in Antalya in June, 1 gave birth in the laboratory and this female with its newborn young were then released. Also young without their mothers were encountered in this colony. It was determined that embryos E-1793 and E-04031 were in earlier stages than embryos E-1795 and E-1796, although they were caught from the same colony (Figure 4).

*Pipistrellus savii* (Bonaparte, 1837)

An individual (1895) obtained from Konya in June had twin embryos (Figure 4). The individual caught from Düzce in September was not pregnant.

*Plecotus auritus* (Linnaeus, 1758)

Four specimens, caught from Nevşehir and Erzurum, were pregnant in June.

*Miniopterus schreibersii* (Kuhl, 1819)

We examined 28 specimens from İzmir, Antalya, Ankara, Ordu, Hatay and Diyarbakır. Gravid females were encountered in April, May and June and lactating ones in June and July (Figure 4). Two specimens caught from Ankara in April and from Kırklareli in August were not pregnant.

## Discussion

Weights given by Kurta and Kunz (1987) for the mothers and neonates of *Rousettus aegyptiacus*, *Rhinolophus ferrumequinum*, *Pipistrellus pipistrellus*, *Eptesicus serotinus* and *Miniopterus schreibersii* were in accordance with the data of these species in Turkey.

Arlettaz (1993) recorded a *Myotis myotis* female carrying 2 male embryos from Switzerland. Nevertheless,

we did not encounter 2 embryos in the *M. myotis* examined.

Hayssen and Kunz (1996) stated that microchiropteran females had larger neonates when they were compared to the maternal weight, whereas megachiropteran females had relatively small embryos. In accordance with their data, in this study, it was determined that a *Rousettus aegyptiacus* female with a body mass 128 g, carried an 13 g embryo and this neonatal weight was 10.1% of maternal weight, although an *Eptesicus serotinus* female with a weight 21 g, had an 4.5 g embryo and this neonatal weight was 21% of maternal weight (Table 1).

Data of our specimens were compared with those given for the bat species from England, Spain, Switzerland, Germany, Italy, Tunisia, Israel, Iraq and Nepal (Baker et al., 1974, Corbet and Southern, 1977; Harrison and Bates, 1991; Barak and Yom-Tov, 1991; Arlettaz, 1993; Ibanez, 1997; Zahn, 1999; Csorba et al., 1999; Russo and Jones, 2000; Christie et al., 2000) (Table 2).

As seen from the table, the gestation period of some Turkish insectivorous bats was generally May and June and the lactation period was June and July. The gestation and lactation periods of the fruit bat were May, July, August and September. In addition, we recorded pregnant insectivorous bat specimens in Adana, nonpregnant ones in Ankara and lactating ones in Adıyaman in July.

Lactating females of *Myotis myotis* were recorded from May to August in Turkey, Germany and Switzerland, whereas Ibanez (1997) stated that pregnant and lactating females were encountered in January in Spain. Baker et al., (1974) recorded a lactating female of *Eptesicus serotinus* in June from Tunisia, while in the same month we captured pregnant and lactating females of this species from Ankara and Trabzon, respectively.

In conclusion, depending on mating capacity and the possibility of adult individuals in the breeding season, pregnant and nonpregnant females and lactating females with newborn young could be encountered in the same colony at the same time.

Table 2. Gestation (G) and lactation (L) months of some bat species from England, Spain, Switzerland, Germany, Italy, Tunisia, Israel, Iraq, Nepal and Turkey (Ja: January, M: March, A: April, Ma: May, J: June, Ju: July, Au: August, S: September, O: October, N: November).

Species	Country	Ja	M	A	Ma	J	Ju	Au	S	O	N
<i>Rousettus aegyptiacus</i>	Turkey				G, L		G				
<i>Rhinolophus ferrumequinum</i>	England (Corbet and Southern, 1977)					L	L	L			
	Nepal (Csorba et al., 1999)			G							
	Turkey			G	G, L	G, L	L				
<i>R. hipposideros</i>	Turkey					G	G, L	L		L	
<i>R. euryale</i>	Turkey				G	G	G				
<i>Myotis myotis</i>	Spain (Ibanez, 1997)	G, L		L	L	L					
	Germany (Zahn, 1999)					L	L				
	Switzerland (Christie et al., 2000)				L	L	L	L			
	Turkey				G, L	G, L	L				
<i>M. blythii</i>	Tunisia (Baker et al., 1974)										G
	Turkey				G	G, L	L		L		
<i>M. emarginatus</i>	Turkey					L					
<i>M. nattereri</i>	Turkey				G						
<i>M. mystacinus</i>	Turkey					L	G, L				
<i>Eptesicus serotinus</i>	Tunisia (Baker et al., 1974)					L					
	Turkey					G, L					
<i>Pipistrellus pipistrellus</i>	England (Corbet and Southern, 1977)					L	L	L			
	Italy (Russo and Jones, 2000)					G					
	Turkey				G, L	G, L					
<i>P. kuhlii</i>	Tunisia (Baker et al., 1974)			G		L					
	North Israel and South Iraq (Harrison and Bates, 1991)		G		G	G					
	Israel (Barak and Yom-Tov, 1991)		G	G	G, L	L	L				
	Turkey				G	G, L					
<i>P. savii</i>	Turkey					G					
<i>Plecotus auritus</i>	Turkey					G					
<i>Miniopterus schreibersii</i>	Turkey			G	G	G, L	L				

## References

- Adams, R.A. 1992. Stages of development and sequence of bone formation in the little brown bat, *Myotis lucifugus*. J. Mamm. 73: 160-167.
- Albayrak, İ. 1990. Doğu Anadolu Yarasaaları (Mammalia: Chiroptera) ve Yayılışları. Doğa- Tr. J. of Zoology. 14: 214-228.
- Albayrak, İ. 1993. Batı Anadolu Yarasaaları ve Yayılışları (Mammalia: Chiroptera). Doğa- Tr. J. of Zoology. 17: 237-257.
- Albayrak, İ. 2003. The Bats of the Eastern Black Sea Region in Turkey (Mammalia:Chiroptera). Turk. J. Zool. 27: 269-273.
- Arlettaz, R. 1993. Une femelle de Grand murin *Myotis myotis* (Mammalia: Chiroptera). Porteuse de deux embryons. Mammalia. 57: 148-149.
- Baker, R.J., Davis, B.L., Jordan R.G., and Binous, A. 1974. Karyotypic and morphometric studies of Tunisian mammals: bats. Mammalia 38: 695-710.
- Benda, P. and Horáček, I. 1998. Bats (Mammalia: Chiroptera) of the Eastern Mediterranean. Part 1. Review of distribution and taxonomy of bats in Turkey. Acta. Soc. Zool. Bohem. 62: 255-313.
- Barak, Y. and Yom-Tov, Y. 1991. The mating system of *Pipistrellus kuhlii* (Microchiroptera) in Israel. Mammalia. 55: 285-292.
- Christe, P., Arlettaz, R. and Vogel, P. 2000. Variation in intensity of a parasitic mite *Spinturnix myoti* in relation to the reproductive cycle and immunocompetence of its bat host *Myotis myotis*. Ecology letters. 3: 207-212.
- Corbet, G. B. and Southern, H. N. 1977. The Handbook of British Mammals. Blackwell Scientific Publications, Great Britain.
- Csorba, G., Kruskop, S.V. and Borissenko, A.V. 1999. Recent records of bats (Chiroptera) from Nepal, with remarks on their natural history. Mammalia. 63: 61-78.
- Cumming, G.S. and Bernard, R.T.F. 1997. Rainfall, food abundance and timing of parturition in African bats. Oecologia. 111: 309-317.
- Harrison, D.L. and Bates, P.J.J. 1991. The Mammals of Arabia. Harrison Zoological Museum. Lakeside Printing. London.
- Hayssen, V. and Kunz, T.H. 1996. Allometry of litter mass in bats: maternal size, wing morphology and phylogeny. J. Mamm. 77: 476-490.
- Ibanez, C., 1997. Winter reproduction in the greater mouse-eared bat (*Myotis myotis*) in South Iberia. J. Zool. Lond. 243: 836-840.
- Kurta, A. and Kunz, T.H. 1987. Size of bats at birth and maternal investment during pregnancy. Symp. Zool. Soc. London. 57: 79-106.
- Lariviere, S. and Ferguson, S.H. 2003. Evolution of induced ovulation in North American carnivores. J. Mamm. 84: 937-947.
- Martin, R.D. and Maclarnon, A.M. 1985. Gestation period neonatal size and maternal investment in placental mammals. Nature. 313:220-223.
- Russo, D. and Jones, G. 2000. The two cryptic species of *Pipistrellus pipistrellus* (Chiroptera: Vespertilionidae) occur in Italy: evidence from echolocation and social calls. Mammalia. 64: 187-197.
- Sachanowicz, K., Bogdanowicz, W. and Michalak, S. 1999. First record of *Taphozous nudiventris* Cretzschmar, 1830 (Chiroptera, Emballonuridae) in Turkey. Mammalia. 63: 105-107.
- Zahn, A. 1999. Reproductive success, colony size and roost temperature in attic-dwelling bat *Myotis myotis*. J. Zool. 247: 275-280.