








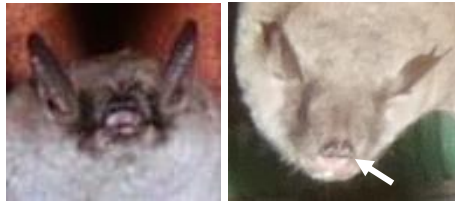

Bat species identification guidelines for camera trap images






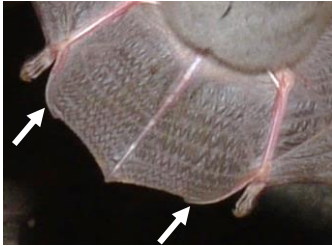


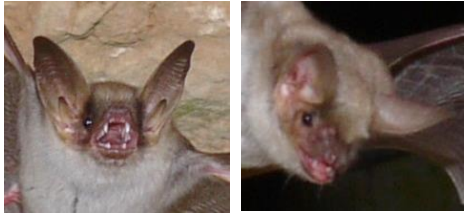
BatNet is an open-source, deep learning-based tool for rapid and accurate bat species identification from camera trap images. The baseline model is trained to identify the following bats species: *Barbastella barbastellus*, *Eptesicus serotinus*, *Myotis bechsteinii*, *M. dasycneme*, *M. daubentonii*, *M. emarginatus*, *M. nattereri*, and *Nyctalus noctula*, and species-complexes: the whiskered bats (*Myotis alcathoe*, *M. brandtii*, *M. mystacinus*), the mouse-eared bats (*M. blythii*, *M. myotis*), the long-eared bats (*Plecotus auritus*, *P. austriacus*), the pipistrelle bats (*Pipistrellus pipistrellus*, *P. pygmaeus*), and the horseshoe bats (*Rhinolophus ferrumequinum*, *R. hipposideros*).






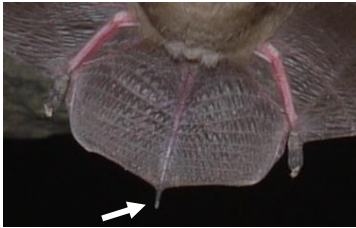



Here we present some practical guidelines for bat species identification from camera trap images, based on morphological characteristics, which can be used when manually reviewing low-confidence *BatNet* identifications.










When using BatNet or the following identification guideline, please cite the following publication:



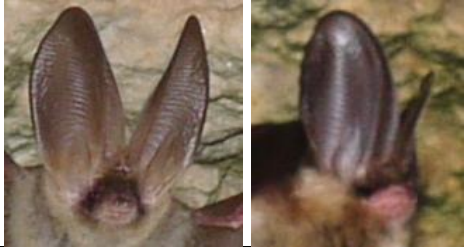
Krivek G., Gillert A., Harder M., Fritze M., Frankowski K., Timm L., Meyer-Olbersleben L., Freiherr von Lukas U., Kerth G., van Schaik J. (2023) *BatNet: a deep learning-based tool for automated bat species identification from camera trap images*, *Remote Sensing in Ecology and Conservation*.

	Daubenton's bat (<i>Myotis daubentonii</i>)	Pond bat (<i>Myotis dasycneme</i>)	Whiskered bats (<i>Myotis brandtii</i> / <i>M. alcaethoe</i> / <i>M. mystacinus</i>)
Example photo (front view)			
Tail	short, heart-shaped 	short, heart-shaped 	looks wrinkled and slightly angular 
Ears/face	relatively short ears with broad base; outer edge of ear with indentation 	relatively short ears; typical “tube- like” nostrils 	relatively long and narrow ears, often dark colored; outer edge of ear with indentation 
Tragus	short, rounded, often not reaching the half length of the ear	short, rounded at its tip, not reaching the half length of the ear	pointy, about half the length of the ear
Wing/feet	relatively large feet	long, broad wings; very large feet	narrow wings; small feet
Color	dorsal fur brown to dark grey-brown; ventral fur greyish-white, juveniles often darker	dorsal fur brown to dark grey-brown with silky sheen; ventral fur greyish-white; dark muzzle	dorsal fur greyish-brown; ventral fur grey; often dark “face mask” and muzzle
Similar species	similar to <i>M. dasycneme</i> , but smaller body and feet; similar to whiskered bats, but larger body, and shorter and broader ears; similar to <i>M. nattereri</i> , but shorter ears with broader base, and shorter tragus	similar to <i>M. daubentonii</i> , but longer ears and much larger body and feet	similar to <i>M. daubentonii</i> , but longer and narrower ears, smaller feet

	Natterer's bat (<i>Myotis nattereri</i>)	Bechstein's bat (<i>Myotis bechsteinii</i>)	Mouse-eared bats (<i>Myotis myotis</i> / <i>M. blythii</i>)
Example photo (front view)			
Tail	long, spur protrudes beyond feet and curved into S-shape 	short, does not reach over feet; straight edge with tail sticking out 	short, does not reach far over feet; round spur 
Ears/face	long, straight ears from front view; tip of the ears bent upwards from side view 	long ears that are clearly separated at their base; outer rim of ears with transverse folds 	long, wide ears; wide ear tip; broad and short nose ("bulldog-face") 
Tragus	spear-shaped, longer than half of the ear	long, thin, lanceolate	lanceolate with broad base, small dark spot at its tip
Wing/feet	small feet	broad, short wings	large, broad wings
Color	dorsal fur brownish-grey; ventral fur light grey to white; sharp border between back and belly	dorsal fur pale to reddish brown; ventral fur light grey	dorsal fur pale to greyish-brown; ventral fur grey
Similar species	similar to <i>M. daubentonii</i> , but longer, narrower ears and tragus; similar to <i>M. bechsteinii</i> , but shorter ears; similar to <i>M. emarginatus</i> , but spur S-shaped (not straight); when facing down, similar to <i>M. myotis</i> , but smaller body and S-shaped spur	similar to <i>M. nattereri</i> , but longer ears with wider base; from side view, similar to <i>Plecotus</i> sp., but longer nose, shorter ears with a gap between the ears at their base	when facing down, similar to <i>M. nattereri</i> , but larger body, and shorter tail, without S-shaped spur; similar to <i>M. bechsteinii</i> , but larger body and shorter ears

	Geoffroy's bat (<i>Myotis emarginatus</i>)	Pipistrelle bats (<i>Pipistrellus pipistrellus</i> /P. <i>pygmaeus</i>)	Serotine bat (<i>Eptesicus serotinus</i>)
Example photo (front view)			
Tail	relatively long, reaches over feet 	longer than feet, round spur 	textured tail membrane; 1-2 tail vertebrae without tail membrane 
Ears/face	straight ears with wide base and right-angled notch on the ear; pointy snout 	short ears with broad base ("triangular") 	relatively long ears; dark face mask and ears 
Tragus	narrow, longer than half-ear length	rounded, slightly curved inwards, reaching about half of the ear length	elongated tragus, rounded at the end, reaching about half of the ear length
Wing/feet	broad wing, small feet	pointed, narrow wings	broad wings
Color	dorsal fur yellow-orange-brown; ventral fur light-greyish; young individuals more grey	dorsal fur dark brown; ventral fur uniform or slightly lighter	dorsal fur very dark reddish-brown; ventral fur yellowish-brown; no clear dividing line between
Similar species	similar to <i>M. nattereri</i> , but spur straight (not S-shaped), notch on the ear, and when facing down, very angular ears (not rounded)	similar to <i>Eptesicus serotinus</i> , but much smaller body, narrower wings, and shorter ears	similar to Pipistrelle bats, but much bigger body, broader wings, longer ears

	Noctule bat (<i>Nyctalus noctula</i>)	Barbastelle bat (<i>Barbastella barbastellus</i>)	Horseshoe bats (<i>Rhinolophus hipposideros</i> / <i>R. ferrumequinum</i>)
Example photo (front view)			
Tail	relatively long, with epibema (post-calcareal lobe, see arrows) 	relatively long tail, textured tail membrane, spur not or barely curved 	short tail and spur 
Ears/face	short, broad, roundish ears with thick edges 	broad, trapezoidal ears, base of ears connected to each other at the nose 	large, drop-shaped ears; typical "horseshoe"-shaped nose 
Tragus	short, mushroom-shaped; antitragus extends from ear to edge of mouth	triangular with long, rounded tip	no tragus
Wing/feet	dark-brown, pointy, narrow wings; hair extends on the wings	long, narrow wings	large, broad wings
Color	smooth and shiny fur; dorsal fur reddish or golden brown; ventral side slightly lighter; dark muzzle	dorsal fur dark grey-black with white tips; ventral fur dark grey	dorsal fur grey-brown; ventral fur light grey; young individuals are dark grey
Similar species	-	-	-

	Long-eared bats <i>(Plecotus auritus/</i> <i>P. austriacus)</i>
Example photo (front view)	
Tail	tail longer than feet, textured tail membrane 
Ears/face	very long ears, connected at their base 
Tragus	wide, lighter color at the base
Wing/feet	broad wing, relatively large feet
Color	dorsal fur light/reddish brown; ventral fur lighter yellowish brown; young individuals are pale grey without brownish tones
Similar species	similar to <i>Myotis bechsteinii</i> , but ears are connected in front at their base by a fold of skin (and not widely separated)