

ECHOLOCATION CALLS OF *Myotis alticraniatus* (CHIROPTERA: VESPERTILIONIDAE) IN VIETNAM

Vu Dinh Thong^{1,2}, Dao Nhan Loi³, Hoang Trung Thanh⁴, Pham Van Nha⁵,
Cao Thi Thanh Nga⁶, Phaly Sengmanichanh⁵, Nguyen Manh Ha², Vu Duc
Toan³, Dinh Van Thai³ and Nguyen Van Viet⁷

¹*Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology*

²*Graduate University of Science and Technology, Vietnam Academy of Science and Technology*

³*Faculty of Agriculture and Forestry, Tay Bac University;*

⁴*Faculty of Biology, University of Science, Vietnam National University;*

⁵*Faculty of Natural Sciences and Technology, Tay Bac University;*

⁶*Institute of Human Geography, Vietnam Academy of Social Sciences;*

⁷*Personel and Student Affair Department, Hai Duong College*

Abstract. *Myotis alticraniatus* is a small mammal species with widespread distribution in Vietnam and other Asian countries. However, prior to the present study, its echolocation calls were poorly documented. Between 2018 and 2020, we conducted bat surveys in Cat Ba National Park and other areas of Vietnam. Echolocation calls of the species were obtained in different recording situations: handheld, flying inside a flight tent and foraging in natural habitats. The average initial frequency (iFM) and terminal frequency (tFM) of this species' echolocation calls are in ranges of 113.2-140 kHz and 57.8-68.6 kHz, respectively. Its call duration is in a range of 1.6-3.9 ms. When detecting an object or prey in natural habitats, the species emitted echolocation calls in groups of up to 10 signals with the iFM and tFM values in ranges of 60.6-64.3 kHz and 28.2-31.0 kHz, respectively. Results from the present study exhibited a wide variation in frequencies and signal shapes of the species echolocation calls.

Keywords: Asia, bat, Cat Ba, mammal, *Myotis*.

1. Introduction

Indochinese Whiskered Myotis (*Myotis alticraniatus*) was first described as a subspecies of Himalayan Whiskered Myotis (*Myotis siligorensis alticraniatus*) from “Mường Mươn” commune, “Mường Chà” district, Dien Bien province, northwestern Vietnam [1]. However, Ruedi et al. reclassified it as a distinct species [2]. To date, the species has been recorded from at least six countries in Asia: Cambodia, China, Laos, Myanmar, Thailand, and Vietnam [3].

Received October 13, 2022. Revised October 24, 2022. Accepted October 31, 2022.

Contact Vu Dinh Thong, e-mail address: thongvudinh@gmail.com

Within Vietnam, *M. alticraniatus* has been recorded from a wide range of habitats and ecosystems including mangroves, islands, and forests through the northern and southern regions [4-6]. However, its echolocation calls were poorly documented in previous publications. Several publications simply included the maximum energy or basic information of this species echolocation calls [4-6]. Therefore, it was almost impossible to acoustically identify this species in the field based on previous descriptions. Between 2018 and 2020, we conducted bat surveys in northern and central Vietnam and obtained comprehensive data in echolocation calls of *M. alticraniatus*. This paper provides a detailed description of this species echolocation calls in different situations in Cat Ba National Park with new findings in frequencies and other sound parameters.

2. Content

2.1. Bat capture and identification

The surveys were conducted in Cat Ba National Park and other areas in northern and central Vietnam following Thong et al. [7-10]. Bats were captured and handled following the guidelines recommended by the American Society of Mammalogists [11, 12]. Harp traps [13] and mist nets (6.0 m height \times 9.0-12.0 m length, mesh size 16 \times 16 mm) were set up under the canopy of plantation or natural vegetation. Every captured individual was morphologically identified following descriptions in previous publications [14-20]. Reproductive status and age were assessed following Racey [21] and Brunet-Rossini and Wilkinson [22] respectively. Juveniles were released and excluded from analyses for identification to reduce the influence of age variations. External features of each captured bat were measured using calipers for comparison with voucher specimens, which were previously collected from Cat Ba National Park and other study sites in Vietnam, deposited at the Institute of Ecology and Biological Resources (IEBR), Hanoi, Vietnam.

2.2. Echolocation recordings and analyses

Bat calls were recorded in different situations: handheld, flying inside a flight tent (5 meters width \times 5 meters length \times 3 meters height), and foraging in natural habitats using the PCTape system (sampling rate of 480 kHz, 16 bit). The calls were also recorded when each individual was released after taking measurements and photographs. The Batman software, which displays color sonograms of every detected echolocation signal in real-time, was used to obtain high-quality sound sequences. The Selena software was applied for analyses of selected sound sequences. Both PCTape and Selena were custom-made by the University of Tuebingen, Germany. Signals were displayed as sonograms with an FFT (Fast Fourier Transformation) of 512, Hann-window, and zero-padding to measure the following call parameters: initial frequency (iFM), terminal frequency (tFM), bandwidth (BW) and pulse duration (PD). The iFM,

tFM and BW were measured in kilohertz (kHz) while PD was measured in milliseconds (ms). These parameters were measured from the first harmonic of each call.

2.3. Results

Twenty-eight individuals of *M. alticraniatus* were captured over the surveys. Of these captured individuals, two were juveniles while the remainders were adult. Morphological characteristics and measurements of the adult individuals were identical to those of the examined specimens deposited at IEBR.

Myotis alticraniatus uses a very typical “frequency-modulated” call. The iFM and tFM values of this species calls are in ranges of 113.2-140.0 kHz and 57.8-70.5 kHz, respectively, while the pulse duration is in a range of 1.6 - 3.9 ms (Table 1). Depending on habitats and environments, the species adjusted its iFM and tFM in ranges of 26,8 kHz and 10,8 kHz, respectively. Echolocation calls of this species are different in signal shapes and PD values among the recording situations (Figure 1, Table 1).

Table 1. Selected sound parameters of *M. alticraniatus* in different recording situations

Recording situations	n	Sound parameters			
		iFM (kHz)	tFM (kHz)	BW (kHz)	PD (ms)
Handheld	4	121.2 ± 5.2	61.8 ± 3.3	59.4 ± 2.8	2.5 ± 0.2
		114.1-126.3	57.8-65.3	56.4-62.9	2.3-2.6
Flying inside a flight tent	6	134.1 ± 6.3	68.4 ± 1.1	65.7 ± 7.4	2.2 ± 0.4
		122.6-140.0	66.7-70.0	52.6-73.3	1.6-2.7
Flying in natural habitats	9	126.2 ± 6.8	68.6 ± 1.3	57.6 ± 6.1	3.3 ± 0.4
		113.2-136.7	66.7-70.5	45.1-66.7	2.8-3.9

Values are given as mean ± standard deviation, and ranges. Acronyms are defined in the section “Echolocation recordings and analyses”.

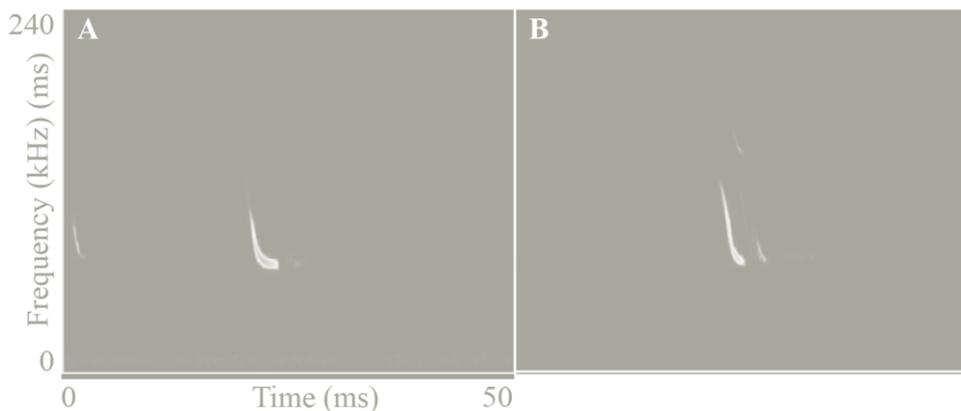


Figure 1. A close-up view of a single echolocation signal of *M. alticraniatus* from Cat Ba National Park while flying in natural habitats (A) and inside a flight tent (B)

During the flight and searching for prey in natural habitats, *M. alticraniatus* emits single downward frequency-modulated call (Figure 2). Data from both observation and recording indicated that, when detecting an object, it emitted echolocation calls in groups up to 10 signals with the iFM and tFM values of 60.6-64.3 kHz and 28.2 - 31.0 kHz, respectively (Figures 3, 4). These parameters were much lower than those of the searching calls.

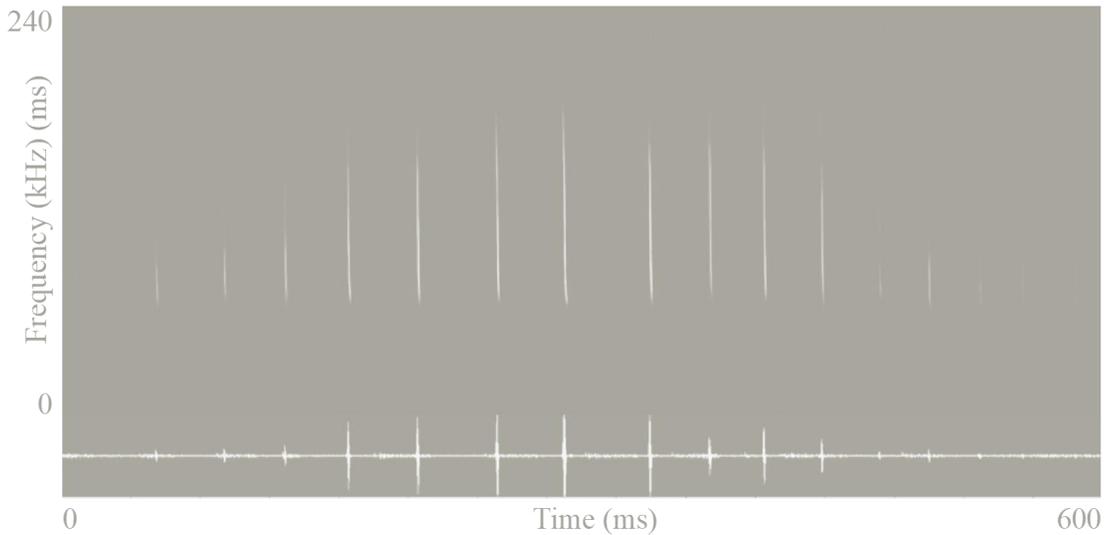


Figure 2. Sonograms and oscillograms of a 600-millisecond sound sequence in natural habitats of *M. alticraniatus* from Cat Ba National Park

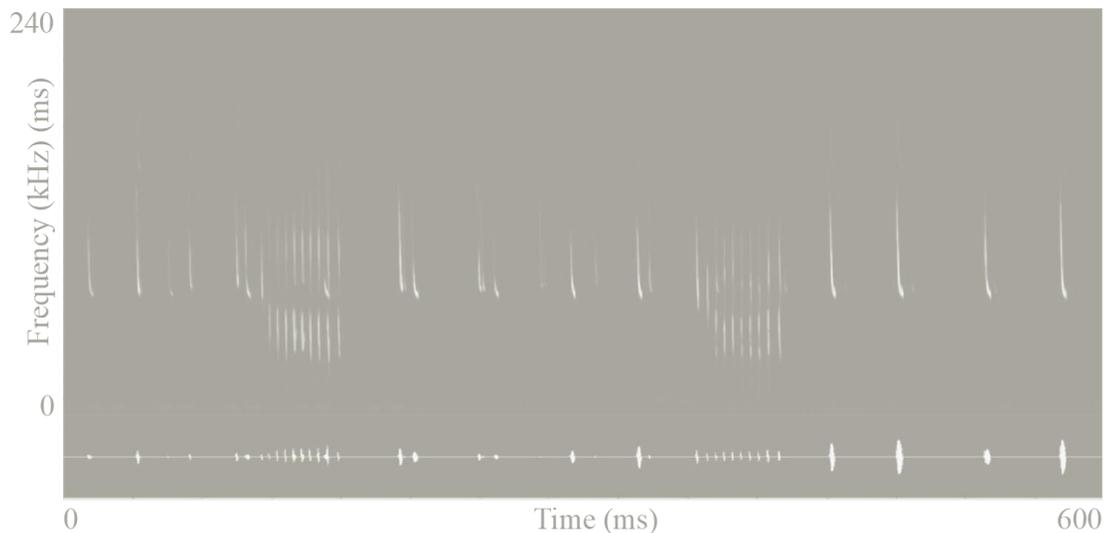


Figure 3. Sonograms and oscillograms of a 600-millisecond sound sequence with signal groups of *M. alticraniatus* in natural habitats from Cat Ba National Park

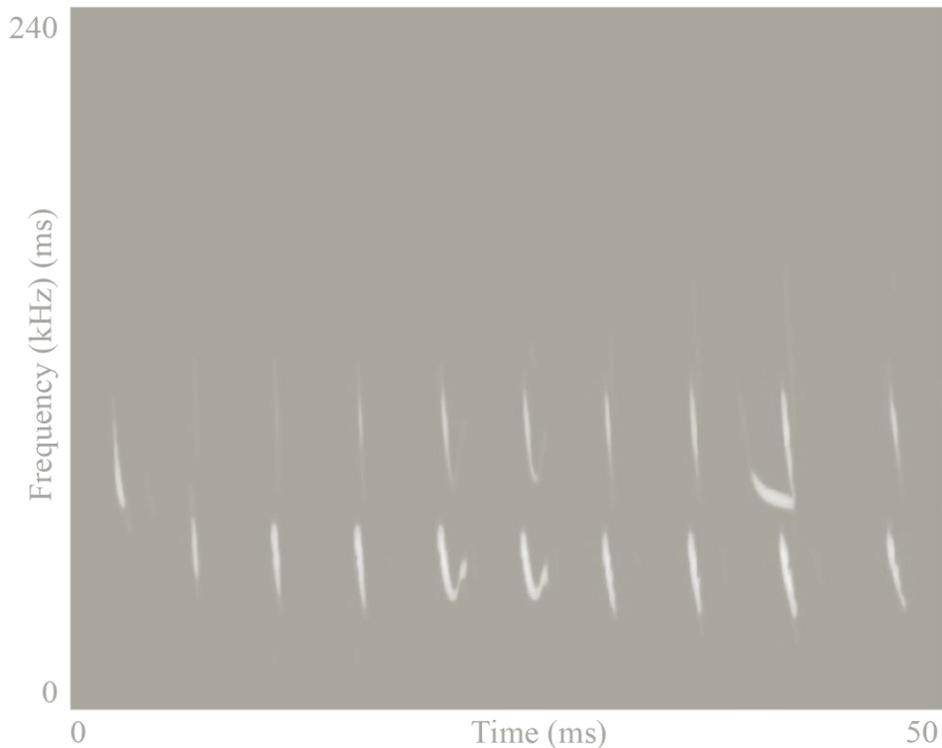


Figure 4. A close-up view of a signal group of *M. alticraniatus* when a bat detected an object in natural habitats in Cat Ba National Park

2.4. Discussion

Myotis alticraniatus is a widespread species with distributional records from Cambodia, China, Laos, Myanmar, Thailand, and Vietnam [3]. Echolocation calls of *M. alticraniatus* from Vietnam and other countries were included in several publications under its former taxonomic status, *Myotis siligorensis alticraniatus* [5, 23, 24]. Furey et al. indicated that “*Myotis siligorensis*” (= *Myotis siligorensis alticraniatus*) uses echolocation calls with iFM, tFM and PD values were 85.0–129.4 kHz, 69.0–78.0 kHz, and 2.3 - 5.2 ms, respectively [23]. Remarkably, the “maximum energy” of this species’ calls was remarkably different in previous publications (45–50 kHz in Kruskop and 75.7–83.4 kHz in Furey et al. [5, 23]). Those different values were likely resulted from different recording situations. Recorded calls are usually affected by recording situations and equipment [25, 26]. All recordings obtained during the present study exhibited the values of iFM and tFM over 100 kHz around 60 kHz, respectively. These are slightly different from the previous records in Vietnam but similar to those of “*Myotis siligorensis*” in Thailand (Table 2). It is very likely that *M. alticraniatus* uses echolocation calls in groups up to 10 signals to increase the accuracy in detecting and locating preys or objects while foraging. Further studies are required to understand this species echolocation behaviour.

Table 2. A comparison of selected sound parameters of *M. alticraniatus* among localities in Vietnam and other countries

Localities	Source	Sound parameters			
		<i>iFM (kHz)</i>	<i>tFM (kHz)</i>	<i>BW (kHz)</i>	<i>PD (ms)</i>
CBNP	The present study	113.2-140.0	57.8-70.5	45.1-73.3	1.6-3.9
KHNR	Furey et al. [23]	85.0-129.4	69,0-78,0	-	2.3-5.2
Thailand	Hughes et al. [24]	141.1 ± 31.7	62.5 ± 4.06	-	3.58

Notes: CBNP = Cat Ba National Park, Hai Phong city, northern Vietnam;
KHNR = Kim Hy Nature Reserve, Bac Kan province, northern Vietnam.

3. Conclusions

Myotis alticraniatus uses typical frequency-modulated echolocation calls with the highest and lowest frequencies in ranges of 113.2-140.0 kHz and 57.8-70.5 kHz, respectively. In natural habitats, while detecting an object or prey, this species emits echolocation calls in groups up to 10 signals with the iFM and tFM values in ranges of 60.6-64.3 kHz and 28.2-31.0 kHz, respectively.

Acknowledgment. The authors would like to thank the Vietnam Academy of Science and Technology under grant number VAST04.03/21-22; the following people and institutions for their various support: Paul A. Racey of the University of Exeter, UK; Tigga Kingston of the Texas Tech University, USA; Paul J.J. Bates of the Harrison Institute, UK; Hans-Ulrich Schnitzler, Annette Denzinger, Christian Dietz of the University of Tuebingen, Germany; Marianne Carter, Stuart Paterson, Christina Imrich, Henry Rees, Leala Rosen, Kate Toiton and Sherilyn Bos of the Conservation Leadership Programme, UK and USA; Doctorates of the Institute of Ecology and Biological Resources, VAST; Pham Duc Tien for field assistance; Nguyen Xuan Khu and Vu Hong Van of Cat Ba National Park for administrative works.

REFERENCES

- [1] Osgood, W.H. 1932. Mammals of the Kelly-Roosevelts and Delacour Asiatic expeditions. Field Museum of Natural History. Publication 312, 18(10): 193-339.
- [2] Ruedi, M., U. Saikia, A. Thabah, T. Görföl, and G. Csorba. 2021. Molecular and morphological revision of small Myotinae from the Himalayas shed new light on the poorly known genus *Submyotodon* (Chiroptera: Vespertilionidae). *Mammalian Biology*, 101, pp. 465-480.
- [3] Simmons, N.B. and A.L. Cirranello. 2022B. Bat Species of the World: A taxonomic and geographic database. Accessed on 10/01/2022.
- [4] Borissenko, A.V., Kruskop, S.V. 2003. *Bats of Vietnam and adjacent territories: an identification manual*. Joint Russian-Vietnamese Science and Technological Tropical Centre, Moscow, Russia.

- [5] Kruskop, S.V. 2013. *Bats of Vietnam: checklist and an identification manual*. Joint Russian-Vietnamese Science and Technological Tropical Centre, Moscow, Russia.
- [6] Viet, N.V., Loi, D.N., Khoi, L.V., Thong, V.D. 2017. Diversity and distribution of bat species of *Pipistrellus* and *Myotis* (Chiroptera: Vespertilionidae) from Vietnam. Proceedings of the 7th National Scientific Conference on Ecology and Biological Resources. Natural Science and Technic Publishing House, pp. 253-258.
- [7] Thong, V.D., Puechmaille, S.J., Denzinger, A., Bates, P.J.J., Dietz, C., Csorba, G., Soisook, P., Teeling, E.C., Matsumura, S., Furey, N., Schnitzler, H.U. 2012. Systematics of the *Hipposideros turpis* complex and a description of a new subspecies from Vietnam. *Mammal Review*, Vol. 42, No. 2, pp. 166-192.
- [8] Thong, V.D. 2022. Bats of Ly Son archipelago, Central Vietnam. *HNUE Journal of Science*, 67(2): 129-136.
- [9] Thong, V.D., Puechmaille, S.J., Denzinger, A., Dietz, C., Csorba, G., Bates, P.J.J., Teeling, E.C., Schnitzler, H.U. 2012. A new species of *Hipposideros* (Chiroptera: Hipposideridae) from Vietnam. *Journal of Mammalogy*, Vol. 93, No. 1, pp. 1-11.
- [10] Thong, V.D., Mao, X., Csorba, G., Bates, P.J.J., Ruedi, M., Viet, N.V., Loi, D.N., Nha, P.V., Chachula, O., Tuan, T.A., Son, N.T., Fukui, D., Tu, V.T., Saikia, U. 2018. First records of *Myotis altarium* (Chiroptera: Vespertilionidae) were from India and Vietnam. *Mammal Study*, Vol. 43, pp. 67-73.
- [11] Sikes, R.S., Gannon, W.L., 2011. The Animal Care and Use Committee of the American Society of Mammalogists. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. *J. Mammal.*, Vol 92, pp. 235-253.
- [12] Sikes, R.S., Animal Care and Use Committee of the American Society of Mammalogists, 2016. Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. *J. Mammal.*, Vol. 97, pp. 663-688.
- [13] Francis, C. M. 1989. A Comparison of Mist Nets and Two Designs of Harp Traps for Capturing Bats. *Journal of Mammalogy*, Vol. 70, No. 4, pp. 865-870.
- [14] Corbet, G. B., Hill, J.E. 1992. *The mammals of the Indomalayan region*. Oxford University Press, Oxford, United Kingdom.
- [15] Bates, P.J.J., Harrison, D.L. 1997. *Bats of the Indian Subcontinent*. Harrison Zoological Museum, Sevenoaks, Kent, United Kingdom.
- [16] Bates, P.J.J., Hendrichsen, D.K., Walston, J.L., Hayes, B. 1999. A review of the mouse-eared bats (Chiroptera: Vespertilionidae: *Myotis*) from Vietnam with significant new records. *Acta Chiropterologica*, 1, pp. 47-74.
- [17] Hendrichsen, D.K., Bates, P.J.J., Hayes, B.D., Walston, J.L. 2001. Recent records of bats (Mammalia: Chiroptera) from Vietnam with six species new to the country. *Myotis*, 39, pp. 35-122.
- [18] Francis, C. M. 2008. *A field guide to the mammals of Southeast Asia*. New Holland Publishers Ltd, UK.
- [19] Loi, D.N., Thong, V.D. 2017. First records of bats (Mammalia: Chiroptera) from Muong Phang Cultural and Historical Site, Dien Bien province, Northeastern Vietnam. *Vietnamese Journal of Biology*, Vol. 39, No. 3, pp. 396-402.

- V.D.Thong, D.N.Loi, H.T.Thanh, P.V.Nha, C.T.T.Nga, P.Sengmanichanh, N.M.Ha, V.D. Toan, D.V.Thai and N.V.Viet
- [20] Thong, V.D. 2021. *Taxonomy and echolocation of Vietnamese bats*. Publishing House for Science and Technology, Hanoi, Vietnam: 258 pp.
- [21] Racey, P.A. 2009. *Reproductive assessment of bats, in Kunz and Parsons: Ecological and Behavioural Methods for the Study of Bats*, 2nd Edition, The John Hopkins University Press.
- [22] Brunet-Rossinni, A. K., Wilkinson, G.S. 2009. *Methods for age estimation and the study of senescence in bats*. In: Kunz T. and Parsons S. (Eds): *Ecological and Behavioural Methods for the Study of Bats*, 2nd Edition: The John Hopkins University Press, p. 315-325.
- [23] Furey, N.M., Mackie, I.J., Racey, P.A. 2009. The role of ultrasonic bat detectors in improving inventory and monitoring surveys in Vietnamese karst bat assemblages. *Current Zoology*, 55(5): 327-341.
- [24] Hughes, A.C., Satasook, C., Bates, P.J.J., Soisook, P., Sritongchuay, T., Jones, G., Bumrungsri, S. 2011. Using Echolocation Calls to Identify Thai Bat Species: Vespertilionidae, Emballonuridae, Nycteridae and Megadermatidae. *Acta Chiropterologica*, 13(2): 447-455.
- [25] Parsons, S. 1998. The effect of recording situation on the echolocation calls of the New Zealand lesser short-tailed bat (*Mystacina tuberculata* Gray). *New Zealand Journal of Zoology*, 25(2), pp. 147-156.
- [26] Pye, J. D. 1992. Equipment and techniques for the study of ultrasonic sound in air. *Bioacoustics* 4: 77-88.