Studies on the Underwater Sound–I

On the Underwater Sound of *Genus Alpheus FABRICIUS* in the Coastal Waters of Japan

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Abstract

Four species of the *genus Alpheus* *FABRICIUS*, so-called snapping shrimps, namely *A. bis-incisus de HAAN*, *A. brevicristatus de HAAN*, *A. rapax FABRICIUS*, and *A. japonicus MIERS*, were caught in the coastal waters of Nagasaki Prefecture and their underwater sounds were recorded. These shrimps emit peculiar pulse which is very powerful. These sounds are emitted by striking of the inside projections of their large chela The duration of this sound(pulse) is less than 18 millisecond and the frequency band reaches more than 7kc. It seems that the frequency of the sound emitted by individual specimen is less than 1 per second. The mechanism of emitting the sound varies by species but their sounds are all pulses which resemble closely Furthermore, a sound spectorogram differs in detail from any other even in the same specimen

In effect, it is guessed that the underwater sound(pulse) emitted by *genus Alpheus* constitutes the largest part of "FRYING NOISE".

Introduction

It is well known that the noise, that is similar to the one made at the time of frying, is heard in the sea. The authors had named this sound "TENPURA NOISE" in Japanese and have long been using this name. The sources of this frying noise have been explained variously but there is no definite opinion. In the course of recording and analysis of the underwater sounds of little toothed whales, fish and so on, the authors are disturbed and troubled by this sound. Therefore, the authors first tried to ascertain the source of frying noise. Recently, it was made known that frying noise seems to be emitted by the life in the sea

In the United State of America, it is already a matter of common sense among the research workers in this field that this noise caused by the underwater sound of snapping shrimp. The authors, however, guess that the sound is caused not only by snapping shrimp but also by other organisms in the sea, namely, shrimps, branacles, shells, etc. It is intended by the authors to record and analyze the underwater sound of those sea organisms in the coastal waters of Japan, to draw a correct conclusion as to whether frying noise is caused by these sea organism or not. In this study, as the first step, the underwater sound of snapping shrimp among the underwater invertebrate was recorded, and the pattern and time-section analysis of its underwater sound were compared with those of frying noise recorded in nature.

There are, indeed, many species which emit underwater sound. However, the underwater sound produced by snapping shrimp is so powerful as to be audible in the air even without any instrument. The underwater sound of snapping shrimp has been studied actively in U.S.A., France, etc. as a part of the study of the underwater sound that promptly progressed after the World War II.

JOHNSON, EVEREST and YOUNG described in detail the distribution, habit, mechanism of sound production, variation of the sound level, etc., of 2 species of the snapping shrimp (*Crangon* and *Synalpheus*)[1]. TAVOLGA showed the spectorogram of the sound of snapping shrimp and insisted that the cause of the coastal frying noise was mostly the underwater sound of snapping shrimp[2]. FISH showed the underwater sound of individual snapping shrimp together with the sonagram of crackling background which was produced mainly by snapping shrimp and stated that the natural incessant crackling was nothing else but the sound of snapping shrimp[3].

Material and Method

On 20 August 1968, 12 specimens of *A. bis-incisus de HAAN* measuring about 1 cm in length were caught at the coast of gravel-bottom nearby the Nomo Fisheries Laboratory of Nagasaki University. Those shrimps were caught by digging some

Fig. 1 Beach in front of Nomo Fisheries Laboratory of Nagasaki University where specimens of *A. bis-incisus* were caught

centimeters of the muddy sand bottom that dried up at the time of ebb tide. Fig. 1 shows the coast adjacent to the Nomo Fisheries Laboratory where the specimens of *A. bis-incisus* were caught. On 23 June 1968, 5 specimens of the same species measuring about 3 cm in length were caught at the coast of Doinokubi, Nagasaki. DOTSU has reported that at Ariake Sea, a pair of gobioid fish, *Apocryptodon bleekeri,* had lived in the hole of these shrimps together with the host pair[1],but the authors could not observe such cohabitation at the above-stated sampling places.

And 50 specimens of *A. brevicristatus de HAAN* were caught at the coast of muddy sand bottom in Tomioka (Amakusa Is.) of Kumamoto Prefecture on 13 May 1968. There is a place where *Zodtera marina* LINNAEUS grows and most of these shrimps were caught at this place. Fig. 2 shows the coast of Tomioka where *A. brevicristatus*

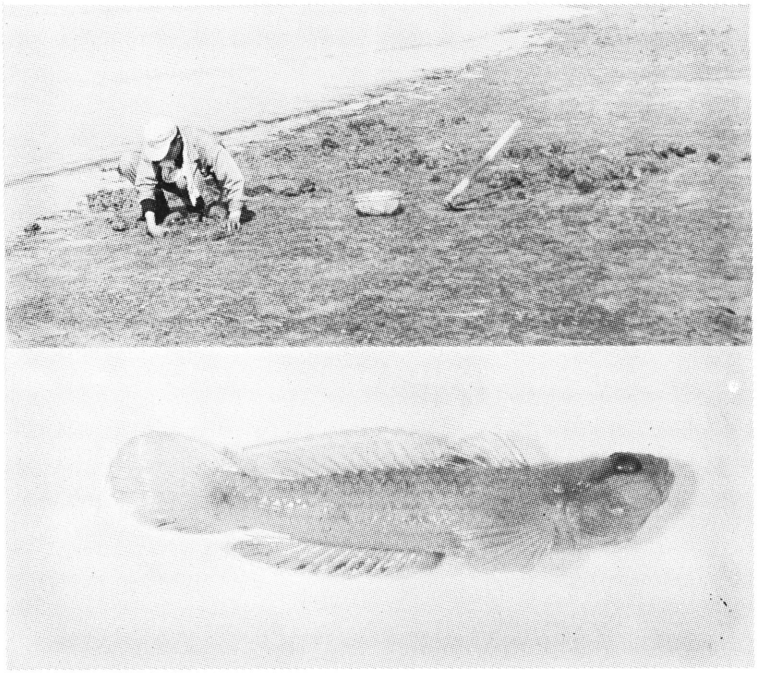

Fig. 2 Upper; Beach of Tomioka, Amakusa Is., where specimens of *A. brevcristatus* were caught
Lower; *Rhinogobius flaumi*

were caught and *Rhinogobius flaumi* which cohabits with this shrimp. When the specimens of *A. brevicristatus* were caught, the female incubated from the first pleopod to the fourth. And one individual of *Rhinogobius flaumi* was caught unfailingly at each hole of *A. brevicristatus.* This shrimp lives at deeper place than *A. bis-incisus* and it is very difficult to catch this shrimp except during the ebb of the spring tide. The fishermen in Tomioka district have been using this shrimp as bait for fishing of the

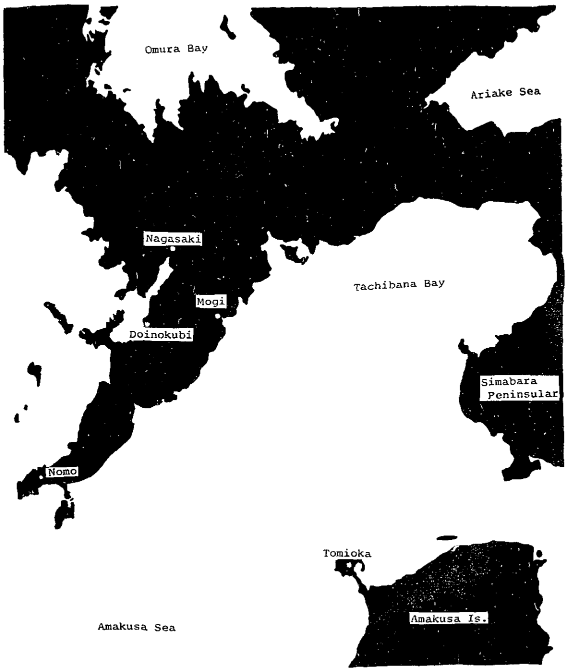

Fig. 3 Location of catch

black porgy, and it is called "JAKU" inokubi district.

A. rapax FABRICIUS (6 specimens) and *A. japonicus* MIERS (2 specimens) were caught together with prawns, squillas, etc., by a small fishing boat by means of snuuevaad from the bottom of Tachibana Bay and Amakusa Sea measuring about 40~60 meters in depth. The location of the catch of these species is shown in Fig. 3.

Upon return of the fishing boat to Mogi, the suburbs of Nagasaki, on 30 May 1968, the specimens were offered to the authors and immediately brought to the laboratory. They were placed in two water tanks, one made of wood measuring 100×70×50cm and the other made of plastic measuring 90×70×50cm, both provided inside with three-folded fleecy rubber carpet. The sounds of these specimens were recorded by hydrophone, pre-amplifier and tape recorder with such method as reported in this Bulletin No. 25 and analyzed for pattern and time-section by the sound spectorograph[5]. The natural frying noise recorded at the time of full tide in Tomioka (Amakusa Is.) where the specimens of *A. brevicristatus* were caught was analyzed by the sound spectorograph for comparison with the former.

Analysis and Discussion

1. Mechanism of sound production

The mechanism of sound production in these shrimps is located in the chela at the terminal of the first periopods. The chela part of the first periopods is different in form between the right and the left, as shown in Fig. 4. One is a larger and has a mechanism of sound production, and the other is smaller and slender. The right chela is larger than the left in most cases, but the contrary is observed in only a few cases. The chela part of this first periopod consists of the dactylus and the propodus,

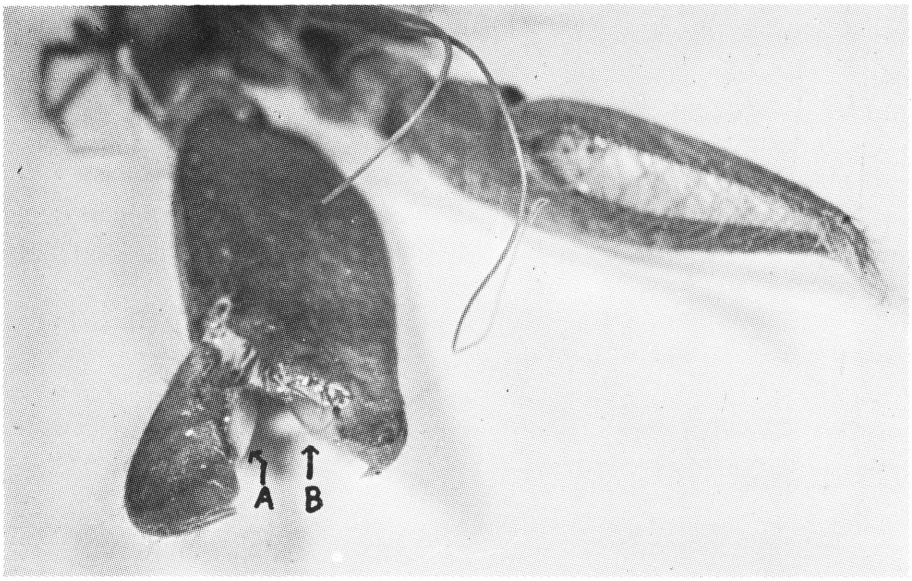

Fig. 4 Chelas of lst. periopods in *A. brevicristatus*,
A is plunger and B is socket

each having inside a projection. The projection of the propodus is a socket and that of the dactylus is plunger. Fig. 4 shows an example in *A. brevicristatus*. When the shrimp closes the chela, these projections severely strike each other and violent pulse is emitted.

To say more precisely, the dactylus is raised slowly, the action of this dactylus is restrained at point (a) in Fig.5. Subsequently, the base of dactylus fall slightly into the propodus and the chela is completely opened. Being acted by the muscle, the ductylus is suddenly set free from the restraint, and as it springs from the propodus, the base of it goes back to the former position and it is closed. At that moment, the plunger fits into the socket.

Such a violent pulse is not heard when the chela is closed from incompletely opened position as well as when it is opened. The time of 1 cycle between opening and closing is about 1 second and when one specimen makes the sound continuously, the repetition rate is about 1 second. Four species of the *genus Alpheus* are shown in the plate. According to this plate, the form of the larger chela is almost the same in the *genus Alpheus* except *A. brevicristatus*. Detailed anatomical investigation of the part of the projections of the chela reveals, however, that one species greatly differs from another. Fig. 5 is the illustration of anatomy. These species are divided into

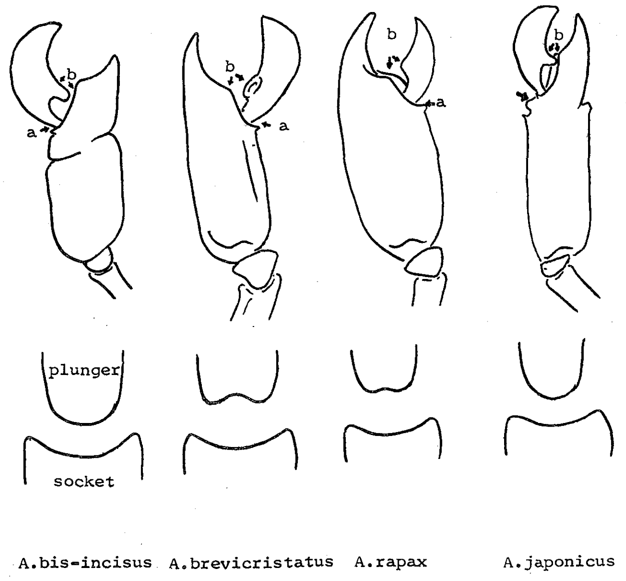

Fig. 5 The illustration of the large chela and the transverse of the projection in 4 species

two groups by the form of the projection (plunger) of dactylus; *A. bis-incisus* and *A. japonicus* in one group and *A. rapax* and *A. brevicristatus* in the other. The tip of the plunger in the former is convex while that in the latter is concave. The projection of the propordus (socket) is about the same in form in all the four species and the contact surface with the plunger is concave.

2. Sound of snapping shrimps

Four species are generally known as the shrimps of the *genus Alpheus* which inhabit in the coastal waters of Japan. They are *A. bis-incisus de Haan*, *A. brevicristatus de Haan*, *A. rapax Fabricius*, and *A. japonicus Miers*, and are shown in plate I. These sounds of snapping shrimps heard through a hydrophone closely resemble and it is quite difficult to distinguish one species from another by the sound. Therefore, these recorded sounds were analyzed by sonagram. The pattern of the sound (pulse) varied not only among different species but also among different individuals of the same species and even in one and the same individual, but no rule for the variation was discovered.

The pattern analysis of the sound produced by snapping shrimps is shown in the plate. The time-section analysis is also shown in the plate together with the above pattern analysis in order to find the energy distribution of each pulse in the frequency band. Plate II-5 is the pattern of pulse of *A. bis-incisus* and Plate II-6 is its time-section. Plate II-7,8 are those of *A. brevicristatus*. And Plate III-9,10 and Plate III-11, 12 are those of *A. rapax* and *A. japonicus* respectively.

Fig. 6 shows the pattern and time-section analysis of natural frying noise recorded at the time of high tide at the every place in Tomioka (Amakusa Is.) where the specimens of *A. brevicristatus* were caught.

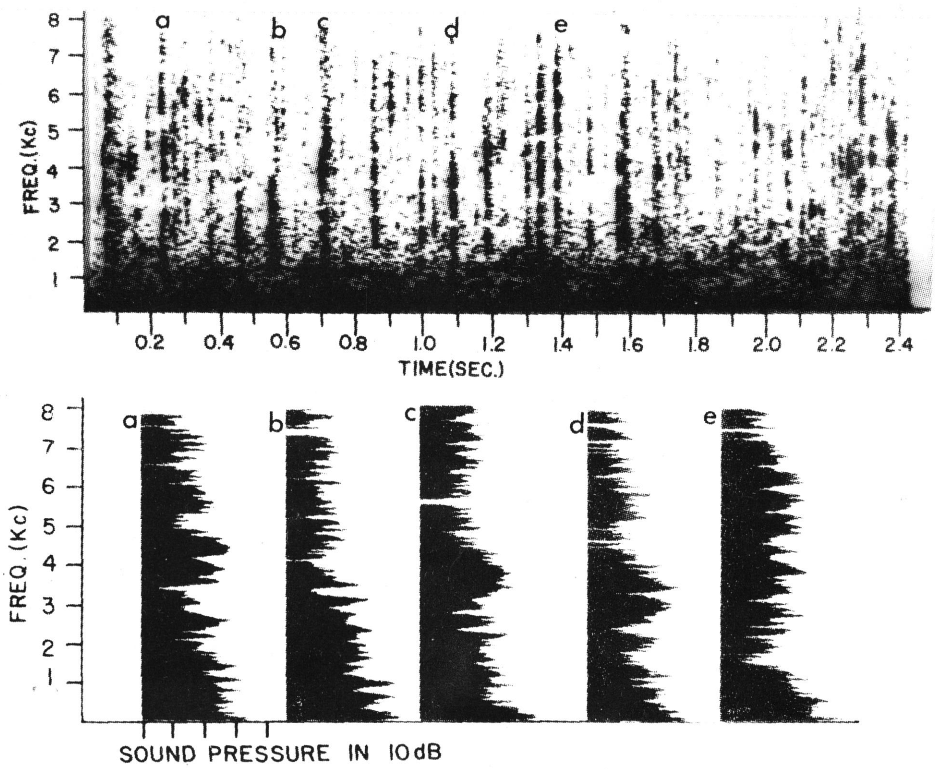

Fig. 6 Upper; Pattern of frying noise shown by sonagram,
Lower; Time-section of frying noise

The pattern and time-section analysis in this figure and those of the pulse of snapping shrimps shown in Plates II,III resemble greatly and it is difficult to recognize any specific difference between the two. Since no life other than snapping shrimp that might possibly emit the pulse was found there, it seems that the cause of frying noise in that area is exclusively the pulse of snapping shrimp. As to the other places, it is readily imagined that there are some other species of marine life that emit the pulse but it seems that the main cause of frying noise is the pulse of snapping shrimp.

Conclusion

1) Four species of the *genus Alpheus* FABRICIUS (*A. bis-incisus de* HAAN, *A. brevicristatus de* HAAN, *A. rapax* FABRICIUS, *A. japonicus* MIERS) were caught near Nagasaki and their underwater sounds were recorded and analyzed.

2) One individual of *Rhinogobius flaumi* was found unfailingly from each habitate (hole) of *A. brevicristatus*. In case of *A. bis-incisus,* the authors could not find any commensal. *A. rapax* and *A. japonicus* were caught at 40~60 m of water depth.
3) The violent sound of these shrimps is caused by mutually striking the projections (socket and plunger) inside of the larger chela of the first periopod.
4) In every species, the duration of the emitted sound is about 18 millisecond and the frequency band of the violent pulse is more than 7 kc.
5) The plunger differed in form by species but its underwater sound as heard by the ear or as analyzed for pattern and time-section failed to serve for distinction of the species.
6) The cause of the frying noise is mainly the pulse emitted by snapping shrimp.

Acknowledgments

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Explanation of Plates

Plate I

Fig. 1 Dorsal view of *Alpheus bis-incisus de* HAAN
Fig. 2 Dorsal view of *Alpheus brevicristatus de* HAAN
Fig. 3 Dorsal view of *Alpheus japonicus* MIERS
Fig. 4 Dorsal view of *Alpheus rapax* FABRICIUS

Plate II

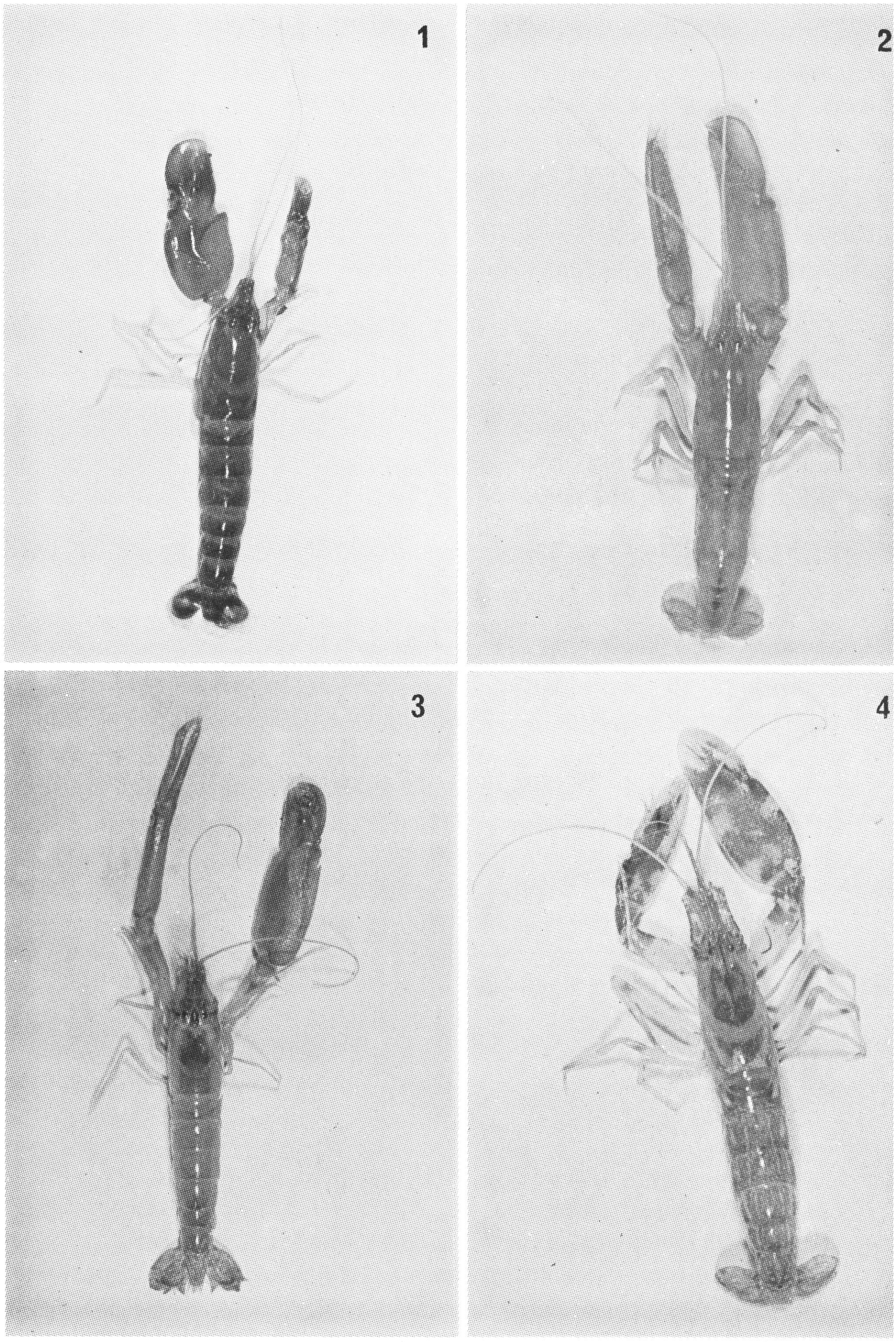
Effective frequency band of these analyses is 45 c/s

Fig. 5 Pattern of the Underwater Sound of *A. bis-incisus*
Fig. 6 Time-section of the Underwater Sound of *A. bis-incisus*
Fig. 7 Pattern of the Underwater Sound of *A. brevicristatus*
Fig. 8 Time-section of the Underwater Sound of *A. brevicristatus*

Plate III

Effective frequency band of these analyses is 45 c/s

Fig. 9 Pattern of the Underwater Sound of *A. japonicus*
Fig. 10 Time-section of the Underwater Sound of *A. japonicus*
Fig. 11 Pattern of the Underwater Sound of *A. rapax*
Fig. 12 Time-section of the Underwater Sound of *A. rapax*



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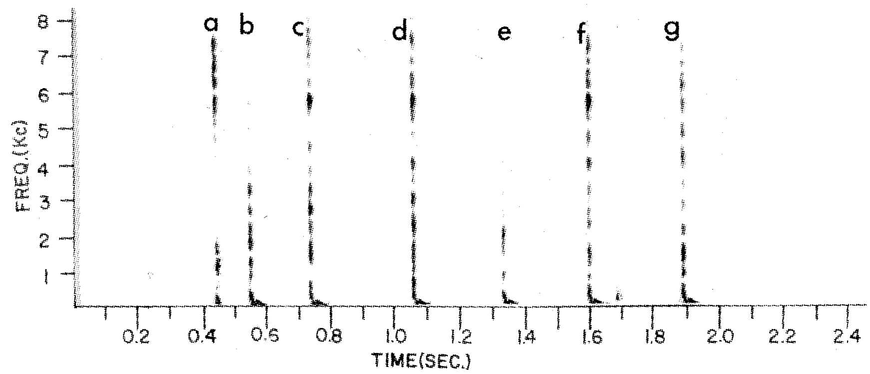

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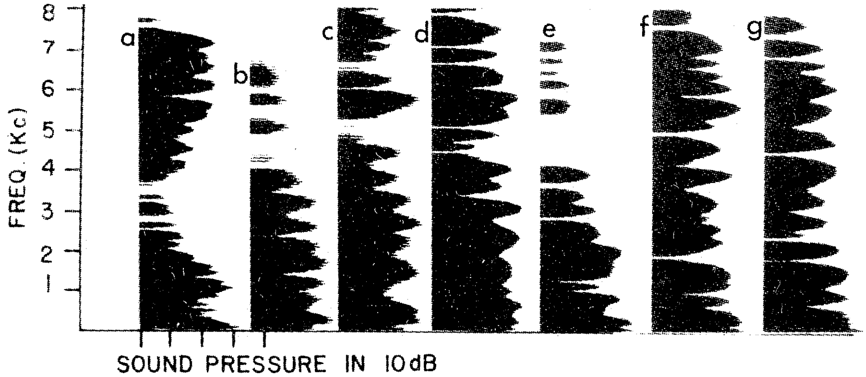

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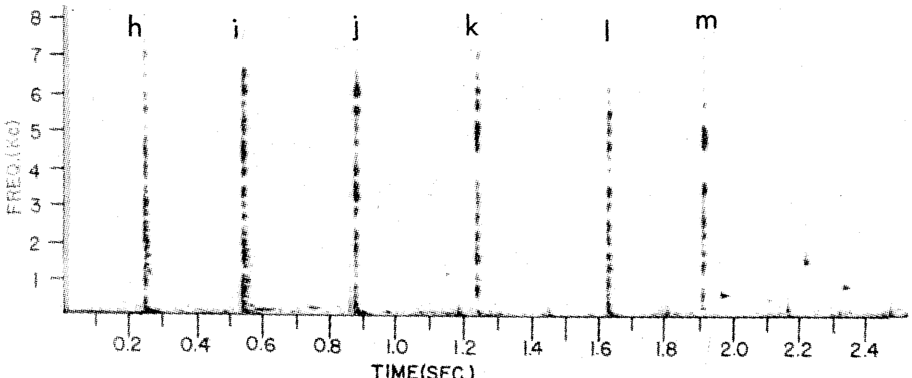

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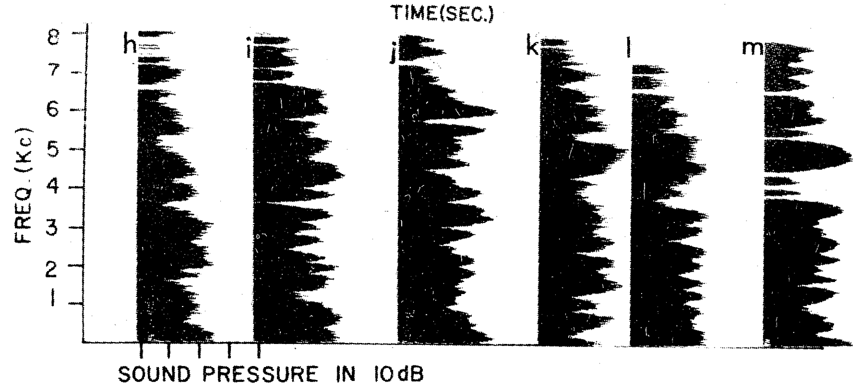

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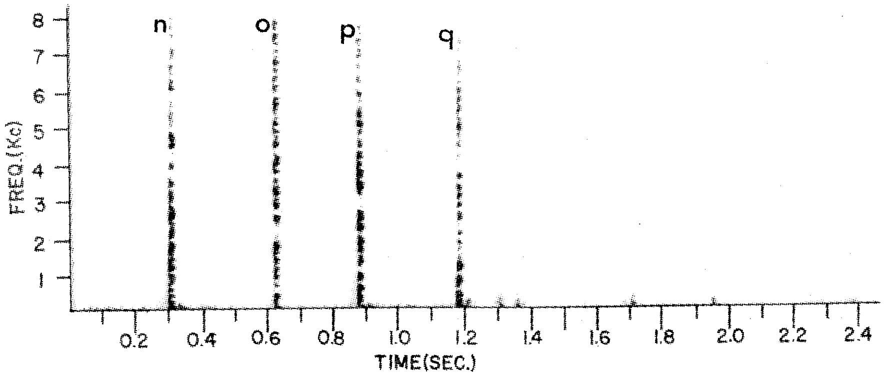
Plate II



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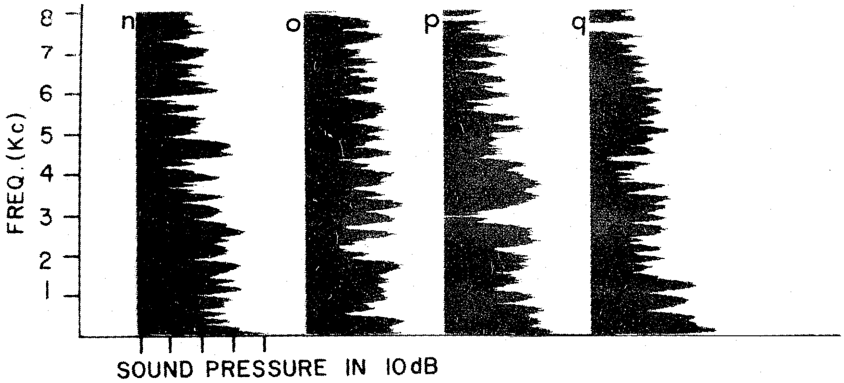

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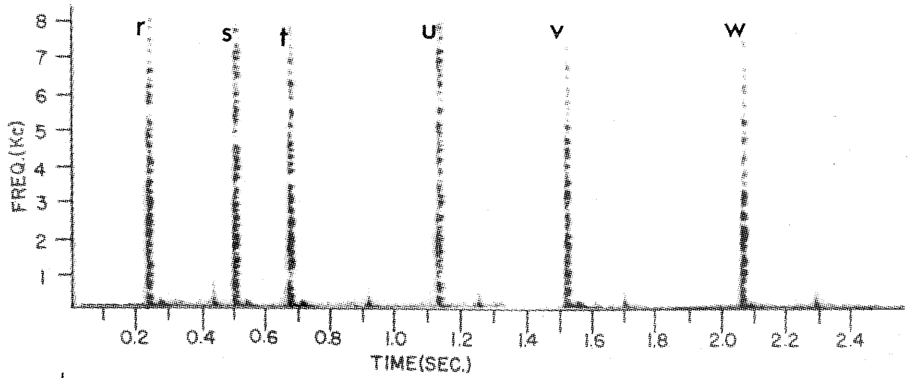

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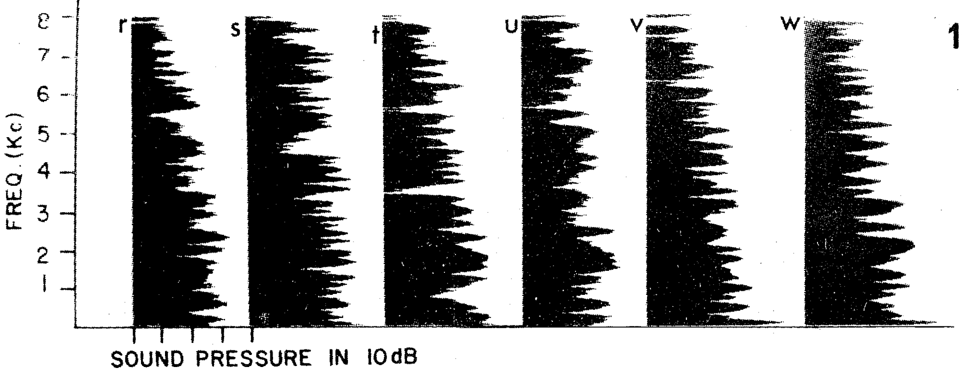

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Plate III