Type of presentation: Poster

ID-13-P-2113 Structure and Biomechanics of Phragmites Australis used for Japanese Double Reed Wind Instrument “Hichiriki”

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Hichiriki is a traditional Japanese double-reed wind instrument (Fig. 1), which has been used in Japanese Gagaku, ancient imperial court music, since the 7th century. The best reeds for hichiriki are made of stems of P. australis that are harvested only from a limited reed bed of Udono in the Yodo River near Kyoto. This resembles that the best reeds for clarinet, oboe and bassoon are produced from stems of Arundo donax L. grown only in a few areas of the Var in France.
We examined the structure of stems of P. australis which were sampled as desirable materials of hichiriki reeds from reed beds along different rivers. Specimens for light microscopy were prepared by cutting the sample pieces to transverse sections about 30 μm thick with a sliding microtome, followed by double staining with safranin and fast green FCF. The hardness and Young’s modulus of different parts on the cross-sectioned surfaces of four hichiriki reeds were measured with a Vickers indentation load of 5 mN using a nanoindentation system (Fischerscope, H100C-XYp). The cross section of the sample was polished using wet sheets of finer grades of sandpaper. Fig. 1c shows the section of the stem from Udono. P. australis almost resembles Arundo donax L in plant anatomical structure but not in outer shape and size of cells. This is the reason why Arundo donax L. cannot be used for hichiriki reeds. Fig. 2 shows the structure of the samples from different reed beds. T is the wall thickness measured from the image. Sample #5 (Udono), to be the best material for hichiriki reed, has a structure where harder materials such as epidermi, hypodermis, and vascular bundle sheath with thick cell walls and softer materials such as parenchyma cells are orderly intermingled, and satisfied the shape condition of an outer diameter of about 11 mm and a wall thickness of about 1 mm. In Fig. 3 and Table 1, the hardness measurements of two hichiriki reeds are illustrated. The reed shown in Fig. 1b, assessed as excellent in musical performance, made from Udono stem is much harder over all the parts than a reed made from a stem sampled from Kitakami River reed bed.

Acknowledgement: We thank Ms. Hitomi Nakamura, the Reigakusha Gagaku Ensemble, for providing samples and valuable comments from a view of musical performance.

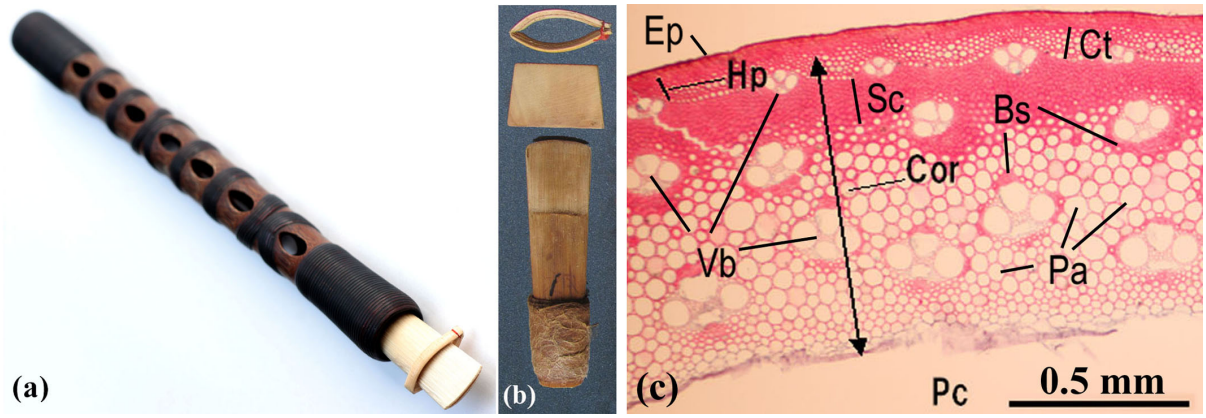

Fig. 1: (a) Japanese double-reed wind instrument 'Hichiriki'. (b) Hichiriki's reed (#R1). (c) Light micrograph of Udono's P. australis. Ep: epidermis. Hp: hypodermis. Vb: vascular bundle. Bs: vascular bundle sheath. Cor: cortex. Pa: parenchyma cell. Ct: Cells with thin cell wall. Sc: Sclerenchymatous cells. Pc: pith cavity.

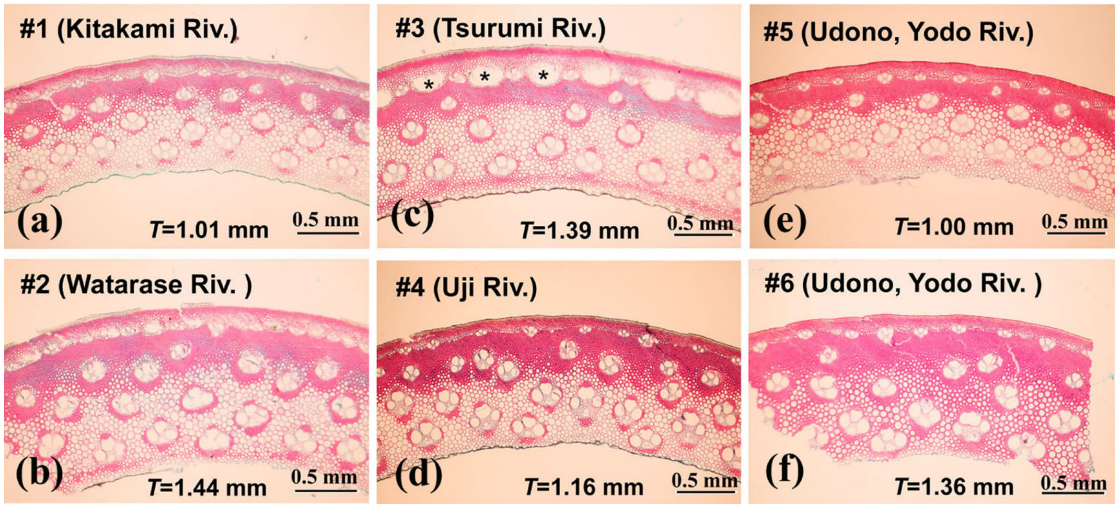

Fig. 2: Light micrographs of P. australis stems from different reed beds. Kitakami Riv. near Sendai, Watarase Riv. near Nikko, Turumi Riv. in Tokyo, Uji Rev. in Kyoto.

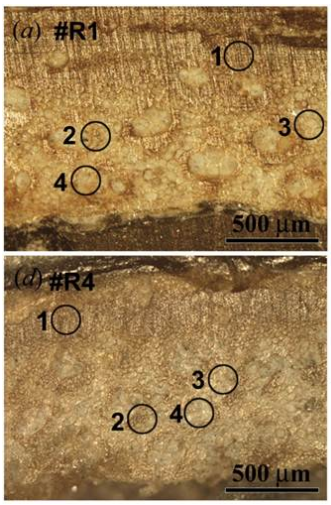

Table 1

		H_{IT} (MPa)	E_{IT} (MPa)
Reed made of stem grown in Udono (#R1)	1	594 ± 65	8530 ± 1255
	2	453 ± 171	4230 ± 1241
	3	301 ± 107	3880 ± 648
	4	243 ± 90	1960 ± 404
Reed made of stem grown in a bed of Kitakami R. (#R4)	1	212 ± 81	6650 ± 1302
	2	167 ± 102	3360 ± 1639
	3	70 ± 20	1520 ± 425
	4	94 ± 41	2240 ± 964

Fig. 3: Crosssections of Udono reed (#R1) (a) and Kitakami reed (#R4) (b). Table 1 Indentation hardness H_{IT} and Young's modulus E_{IT} of different parts shown in (a) and (b).