Phytotaxa 275 (3): 243–262
http://www.mapress.com/j/pt/

Article

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

http://dx.doi.org/10.11646/phytotaxa.275.3.3

Morphometric analysis reveals a new species of *Aponogeton* (Aponogetonaceae) in Sri Lanka

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Abstract

A morphometric analysis of Sri Lankan *Aponogeton* was performed in order to clarify species delimitations and to facilitate their identifications by comparing states coded for 61 vegetative and reproductive characters. Both cluster analysis and principal coordinate analysis resolved five discrete phenetic groups within the genus in the island. Four of these clusters corresponded well with the four previously reported species (*A. rigidifolius*, *A. jacobsenii*, *A. crispus* and *A. natans*) whereas a fifth cluster delimited a new *Aponogeton* species, *A. dassanayakei,* from the wet lowland regions of Sri Lanka. These analyses have disclosed more useful characters for field identification of the species.

Key Words: *Aponogeton dassanayakei,* Aquatic plants, Cluster analysis, Morphology, Phenetics

Introduction

Despite its small size (65,610 km^2), Sri Lanka contains a rich and diverse flora. The island is known to harbor 3,154 flowering plant species (MOE 2012) but potentially contains many that remain undescribed. About 370 species (<12% of total) represent aquatic or wetland plants, wherein 205 (6% of total) are monocots, which include the genus *Aponogeton* Linnaeus f. (1781[1782]: 32) (Yakandawala 2012).

All species of *Aponogeton* (Alismatales: Aponogetonaceae) are obligate, aquatic (freshwater) plants, which are distributed mainly in the tropical or subtropical regions of the Old World (Les *et al*. 2005). In Sri Lanka, the genus is represented by four indigenous species; *Aponogeton rigidifolius* Bruggen (1962: 91), *A. jacobsenii* Bruggen (1983: 120), *A. crispus* Thunberg (1784: 73), and *A. natans* (Linnaeus 1767: 227) Engler & Krause (1906: 11). Of these, the former two are both endemic and endangered (Bruggen 1987, Yakandawala 2012). All of the species are known by the vernacular name "Kekatiya" (in Sinhala) and are popular aquarium plants.

Since the genus *Aponogeton* was first erected by Linnaeus fil. in 1781 (Yadav & Gaikwad 2003), a comprehensive taxonomic treatment of the group was wanting for more than two centuries until Bruggen (1985) recognized 43 species in his pioneering monograph. Subsequent workers added additional taxa and about 58 species are presently recorded worldwide (Guillarmod 1978, Sundararaghavan *et al.* 1982, Hellquist & Jacobs 1998, Yadav & Gaikwad 2003, Jacobs *et al*. 2006, Ali 2008, Chen *et al*. 2015, Yadav *et al*. 2015). The only major taxonomic study to include Sri Lankan *Aponogeton* was that of Bruggen (1985 &1987) and to date there has not been a major revision of the genus. During the course of recent fieldwork on the aquatic flora of Sri Lanka, a number of *Aponogeton* populations were encountered, which contained individuals that were difficult to identify because of inconsistencies with the patterns of morphological variation described in prior taxonomic studies. In an effort to better understand the taxonomy of Sri Lankan *Aponogeton*, a morphometric analysis was conducted from material collected throughout the island as a means of elucidating species delimitations and to develop a more competent approach for their identification.

Materials and Methods

Sample collection

Seventy *Aponogeton* plants from 28 Sri Lankan populations (collected from all suitable habitats located throughout the island) comprised the operational taxonomic units (OTUs) included in this study; each population was denoted by a unique acronym to facilitate its reference (Fig. 1, Table 1). These collections included material assigned to all of the currently recognized *Aponogeton* species on the island as well as providing a comprehensive sample of morphological variation with respect to both their flowering and fruiting stages. Representative samples of each population also were grown and maintained at the Department of Botany, University of Peradeniya, Sri Lanka to provide living reference material for consultation during the course of the study. Voucher specimens for all collections were deposited at The National Herbarium, Peradeniya, Sri Lanka (Appendix 1)

TABLE 1. Field localities and acronym assigned to Sri Lankan populations sampled in this study.

Locality	Acronym	Locality	Acronym
Naula (Matale)	A1–A2	Wanduramba (Galle)	O43–O44
Pidurangala (Matale)	B3–B4	Ittapane (Kalutara)	P45–P46
Pidurangala (Matale)	C5–C6	Lunuganga (Kalutara)	Q47–Q48
Batticaloa (Batticaloa)	D7–D9	Tirappane (Anuradhapura)	R49–R50
Hanwella (Colombo)	E10–E11	Kebithigollewa(Anuradhapura)	S51–S52
Kottawa (Galle)	F12–F14	Tittagonewewa(Anuradhapura)	T53–T54
Kanneliya (Galle)	G15–G17	Muliyarkulam (Vavunia)	U55–U56
Meegama (Kalutara)	H1–H20	Murunkan (Mannar)	V57–V58
Lunuganga (Kalutara)	I21–I23	Murunkan (Mannar)	W59–W60
Delgoda (Kalutara)	J24–J26	Horton plains (N' Eliya)	X61–X62
Royal Botanical Garden	K27	Ganemulla (Gampaha)	Y63–Y64
Horton plains (N' Eliya)	L28–L30	Yagoda (Gampaha)	Z65–Z66
Somawathiya (Polonnaruwa)	M31–M40	Batticaloa (Batticaloa)	AA67–AA68
Sinharaja (Galle)	N41–N42	Kuruwita (Ratnapura)	AB69–AB70

Morphometric Analysis

Sixty-one morphological characters, representing 29 vegetative and 32 reproductive features, including those emphasized as important taxonomically by Bruggen (1985 &1987), were scored for analysis (Table 2) (Appendix 2). Characters were scored from 5–10 individuals in each population with five measurements taken per character in the case of quantitative characters; in these instances, the mean values represented the character states evaluated.

Although scoring for most of the qualitative characters is self-explanatory, two are clarified further. For floret spacing (i.e., the space between florets in the inflorescence), the character states were defined as: 'loose' = >5 mm; 'slightly dense' = <5 mm but >0 mm; or 'dense' = 0 mm. For stamen filament shape: 'linear'= filament width equal from top to bottom; 'slightly dilated' = filament width uniform in upper half, broadened slightly in lower half; and 'broadly dilated' = filament width increasing from top to bottom into a broadly expanded base. All characters and their corresponding character states were assembled into a data matrix, which was analyzed (as follows) using version 2.15 of the PAST software program (Hammer *et al*. 2001).

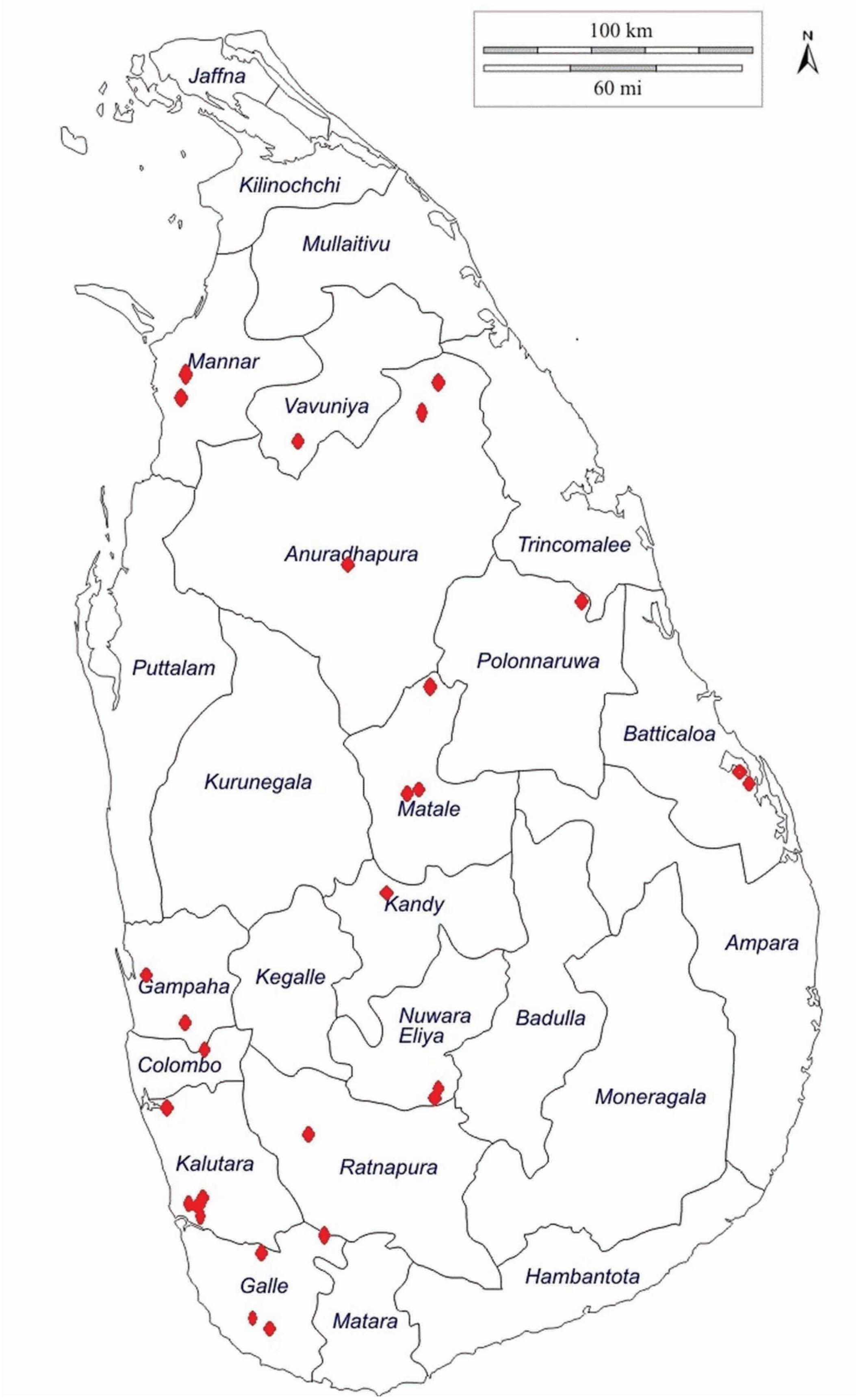

FIGURE 1. Map of Sri Lanka indicating the sample collection locations (N 5º55'–9º55' / E 79º42'–81º52').

Two analyses were performed using PAST. First, the Gower similarity measure option was selected to generate a range-normalized Manhattan distance matrix. We input this matrix into a hierarchical cluster analysis (CA) by selecting the 'paired group' (UPGMA) option to depict the phenetic relationships among all OTUs as a dendrogram. We then performed an ordination analysis using the Gower measure option (transformation exponent C=2) to generate a distance matrix for use in a principal coordinates analysis (Davis 1986). Following the results of these analyses, each major, consistently recovered cluster was identified and where possible, associated with a specific taxon using taxonomic literature references (Bruggen 1985 & 1987).

TABLE 2. Morphological characters and character states evaluated in the study (sub = submersed; flo = floating; NA = not applicable).

Vegetative characters:
1. sub leaves (absent=0, present=1); **2.** flo leaves (absent=0, present=1); **3.** flo leaf habit (NA=0, never erect=1, sometimes erect=2); **4.** root stock (rhizome=1, tuber=2); **5.** tuber shape (NA=0, globular=1, cylindrical=2); **6.** root stock length (cm); **7.** root stock width (cm); **8.** sub petiole length (cm); **9.** sub petiole width (cm); **10.** sub petiole shape (triangular=0, grooved=1 , NA= 2); **11.** sub leaf length (cm); **12.** sub leaf width (cm); **13.** sub leaf margin (flat=0, undulate=1, undulate and/or flat=2, NA=3); **14.** undulation type (type 1=0, type 2=1, type 3=2, type 4=3, NA=4); **15.** flo leaves twisted around midrib (no=0, yes=1, NA=2); **16.** sub leaf tip (narrowly acute=0, acute =1, retuse=2, NA=3); **17.** sub leaf base (acute=0, cordate=1,NA=2); **18.** sub leaf texture (type 1=0, type 2=1, type 3=2, NA=3); **19.** sub leaf primary vein number (#); **20.** flo leaf petiole length (cm); **21.** flo leaf petiole width (cm); **22.** flo leaf petiole cross section (triangular=0, V-shaped=1, NA=2); **23.** flo leaf length (cm); **24.** flo leaf width (cm); **25.** flo leaf margin (flat =0, undulate=1, NA=2); **26.** flo leaf base (cordate type 1=0, cordate type 2=1, NA=2); **27.** flo leaf texture (type 4=0, type 5=1, NA=2); **28.** flo leaf primary vein number (#); **29.** flo leaf midrib (flat=0, protruding=1, grooved=2, NA=3).
Reproductive characters:
30. peduncle (proliferous=0, not proliferous=1); 3**1.** peduncle shape (widened apically=0, width uniform=1); **32.** peduncle length (cm); **33.** spathe duration (caducous=0, persistent=1); **34.** inflorescence length (cm); **35.** inflorescence width (mm); **36.** floret spacing (loose=0, slightly dense=1, dense=2); **37.** tepal number (#); **38.** tepal colour (white=0, pinkish white=1, purple=2); **39.** tepal length (mm); **40.** tepal width (mm); **41.** tepal length: width (ratio); **42.** nerve number (#); **43.** stamen number (#); **44.** filament shape (linear =0, slightly dilated=1, broadly dilated=2); **45.** stamen length (mm); **46.** anther colour (light purple=0, dark purple=1, grayish green=2, brown=3); **47.** carpel number (#); **48.** gynoecium length (mm); **49.** gynoecium width (mm); **50.** mature gynoecium colour (white=0, light pink=1, dark pink=2, purple=3); **51.** ovules per carpel (#); **52.** fruit texture (rough=0, smooth=1); **53.** fruit shape (elongate=0, broadly triangular =1, globular=2); **54.** testa number (#); **55.** outer-testa thickness (thick=0, thin=1) ; **56.** outer-testa texture (smooth=0, ridged=1); **57.** inner-testa (absent=0, present=1); **58.** seed length (mm); **59.** seed width (mm); **60.** plumule (absent=0, present=1); **61.** embryo attachment (at base=0, at or above middle=1, NA=2).

Results

The UPGMA dendrogram (cophenetic correlation coefficient=0.9848) resolved five discrete clusters of OTUs (hereafter clusters 1–5), which separated respectively at approximately 0.16, 0.20, 0.30, and 0.53 distance units (Fig. 2). The OTUs within each cluster grouped together closely, with none of them exceeding a distance of more than 0.07 units within any given cluster (Fig. 2). The first four (principal) eigen values recovered from the PCoA (3.9149, 0.6801, 0.1606, and 0.1180) accounted for 91% of the total variance (73%, 13%, 3%, and 2% respectively). A plot of the first and third coordinates (which provided the greatest separation of OTUs) returned a result similar to that obtained by the CA. Here the PCoA also resolved five discrete clusters (Fig. 3), with each corresponding exactly to one of the clusters indicated by the UPGMA dendrogram (Fig. 2). Although cluster 1 overlapped with cluster 2 along the first coordinate axis, there was no overlap between any of clusters 2–5; however, cluster 1 separated widely from cluster 2 and all other clusters along coordinate 3 (Fig. 3).

Taxonomic descriptions (Bruggen 1985 & 1987) enabled us to explicitly associate three *Aponogeton* species with three of the consistently recovered clusters: *A. crispus* (cluster 4), *A. jacobsenii* (cluster 3), and *A. rigidifolius* (cluster 1). Cluster 2 contained OTUs similar to *A. rigidifolius*, and the most distant cluster (cluster 5) did not precisely match existing descriptions for *A. natans*, a fourth species attributed to Sri Lanka.

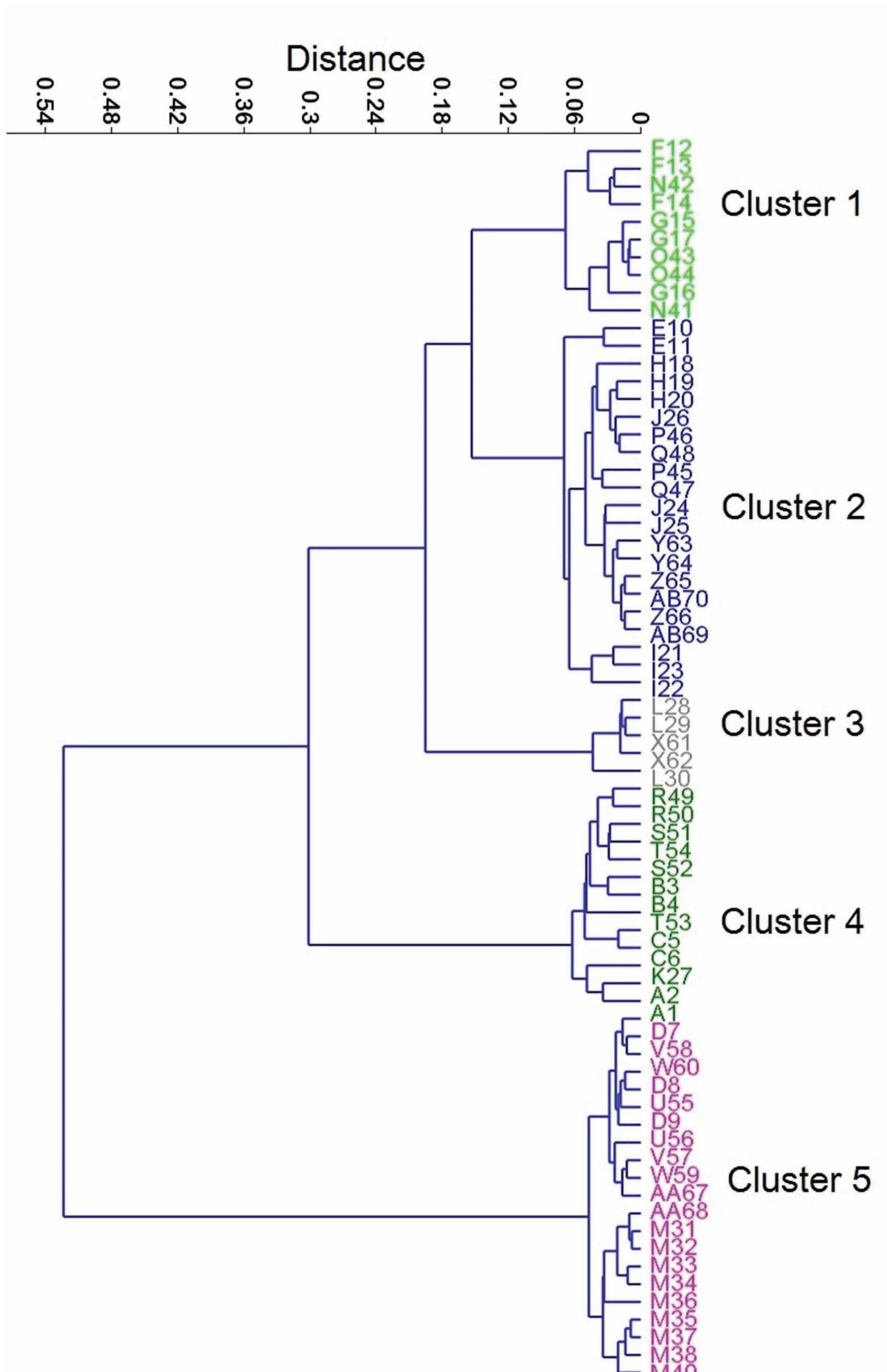

FIGURE 2. A dendrogram resulting from CA resolves five distinct groups of OTUs among the *Aponogeton* material evaluated in this study.

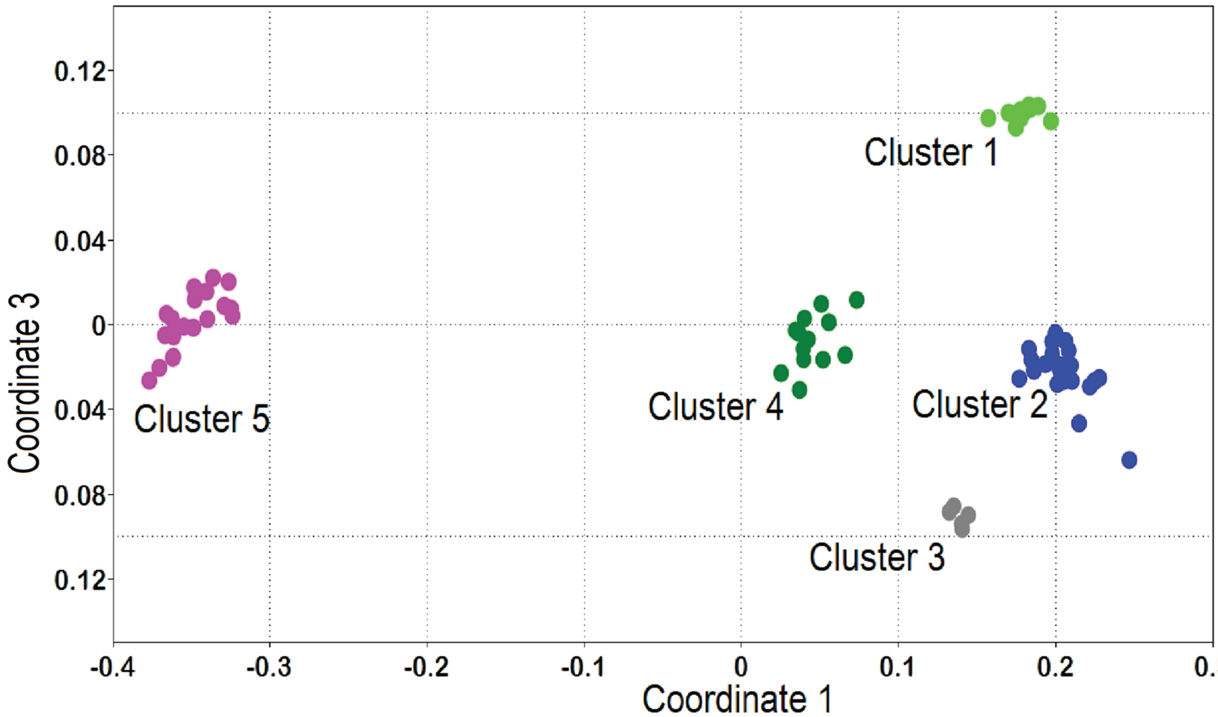

FIGURE 3. Scatter plot resulting from PCoA showing the five distinct clusters of *Aponogeton* OTUs generated from the study material evaluated.

Discussion

Results of the CA and PCoA analyses consistently indicated five discrete phenetic groups of *Aponogeton* OTUs in the Sri Lankan flora. Three of these clusters (1, 3 and 4) could be assigned readily to three species attributed previously to Sri Lanka, namely *A. rigidifolius*, *A. jacobsenii*, and *A. crispus* respectively.

The OTUs associated with cluster 5 did not completely agree with the morphological descriptions of *A. natans*, which has been described and illustrated as a plant having both floating and submersed leaves (Bruggen 1985 & 1987, Cook 1996, Yadav & Gaikwad 2003, Wijesundara & Shantha siri 2004, Ali 2008). None of the OTUs in cluster 5 possessed submersed leaves but they were all erect or emergent, which apparently developed into floating leaves when the plants became inundated during the rainy seasons. We have recently clarified this discrepancy by demonstrating that *A. natans* actually is a species with no submersed leaves (Manawaduage *et al*. 2016).

The identity of cluster 2 OTUs represented a more difficult challenge, given that all of the known Sri Lankan *Aponogeton* species already had been accounted for by OTUs in clusters 1, 3, 4 and 5. The close phenetic association of cluster 1 and 2 OTUs by morphometric analysis (Fig. 2; 0.16 distance units) closely grouped the latter cluster with *A. rigidifolius*. Comparatively, the OTUs in both clusters were more similar morphologically to each other than to any of the OTUs assigned to the other species. By their fully submerged, undulate leaves and emergent, white-flowered inflorescences, one might readily assign cluster 2 OTUs to *A. rigidifolius*. Yet upon closer examination, the OTUs in cluster 2 differed from *A. rigidifolius* by the presence of a tuber instead of a rhizome, and by their longer, highly undulated, and brownish green coloured leaves as opposed to the shorter, less undulated or flattened, and dark purplish-green leaves of *A. rigidifolius*. These differences provide practical characters for separating the two taxa in the field.

Although this undescribed species bears some resemblance to *A. rigidifolius*, it also displays a number of differences. The endemic *A. rigidifolius* is confined to few locations in the low land wet zone of Sri Lanka. Although cluster 2 OTUs also occur in the low land wet zone, they exhibit a wider distribution. These taxa also differ ecologically, with *A. rigidifolius* occurring in stony, rapidly flowing fresh water streams, while the members of cluster 2 OTUs occur in slow flowing rivulets or rivers in much deeper water (below 1–2 m in some cases). The cluster 2 plants also occur nearer to the lagoons, where we have never encountered *A. rigidifolius*.

FIGURE 4. Proliferous peduncle of *Aponogeton dassanayakei* Manawaduge & Yakandawala (specimen collected on 11/08/2014 from Lunuganga (Kalutara), GPS location: N 06° 24. 254 ′ / E 80° 01.121′).

Further, we observed that some cluster 2 OTUs uniquely possessed a proliferous peduncle (Fig. 4), which is a character that never had been recorded previously for any Sri Lankan *Aponogeton*, including *A. rigidifolius*. In cluster 2 plants, vegetative propagation can occur by the formation of young plantlets/propagules (rather than an inflorescence), which develop at the tip of a peduncle-like axis. Further, the proliferous peduncle character was always associated with individuals growing in close proximity to more saline waters. However, none of the plants with proliferous peduncles considered during the study bore an inflorescence on the same individual.

Proliferous peduncles occur rarely in *Aponogeton* and have been reported previously in only two species: *A. proliferous* C.B. Hellquist & S.W.L. Jacobs (1998: 11), an Australian species with yellow-flowered inflorescences and *A. undulatus* Roxburgh (1832: 211), an Asian species with white-flowered inflorescences (Bruggen 1985, Hellquist & Jacobs 1998, Les *et al*. 2005). Of these, *A. proliferous* is distinct from cluster 2 OTUs by its yellow tepals. In a non-taxonomic study, Thabrew & Thabrew (1983) recorded "*A. undulatus*" from Sri Lanka, but provided no distinguishing features for its identification. Morphologically, *A. undulatus* appears to be much closer to members of cluster 2 than to cluster 1. However, unlike the strictly submersed foliage of cluster 2 OTUs, *A. undulatus* possesses both floating and submerged leaves (Bruggen 1985, Yadav & Gaikwad 2003). Cluster 2 OTUs also possess much longer, finer, and more heavily undulated submerged leaves, which (unlike *A. undulatus*) sometimes twist around their mid rib (often in two to three spirals). Their submerged leaves also lack the alternating transparent and opaque areas that are characteristic of *A. undulatus*. Their caducous spathe also contrasts with the persistent spathe ascribed to *A. undulatus* (Bruggen 1985, Yadav & Gaikwad 2003). The tepals of *A. undulatus* are elongate; whereas, those of cluster 2 OUTs are more spherical (Bruggen 1985, Yadav & Gaikwad 2003), and are considerably wider than long. Further, the tepals are persistent and remain on the infructescence below the developing ovaries; whereas, the tepals of *A. undulatus* are caducous (Bruggen 1985, Yadav & Gaikwad 2003) (Fig. 5). From our observations, all of these characters are stable and are not altered substantially by environmental factors.

FIGURE 5. Persistent tepals in a mature inflorescence from *Aponogeton dassanayakei* Manawaduge & Yakandawala (specimen collected on 11/08/2014 from Lunuganga (Kalutara), GPS location: N 06° 24. 254 ′ / E 80° 01.121′).

Thus, the particular combination of traits specific to cluster 2 OTUs is not found in any previously described *Aponogeton* species. For this reason we conclude that these OTUs represent a new, undescribed *Aponogeton* species. A formal description with the illustration (Fig. 6) to the new species is given below. In summary, our morphometric analysis of Sri Lankan *Aponogeton* supports the recognition of five distinct species in the country, which include four previously reported species along with a novel species. Combined with field observations, these analyses also have disclosed errors in the morphological description of *A. natans*, to which submersed leaves have been associated erroneously. Further studies of Sri Lankan *Aponogeton* using molecular data currently are underway and hopefully will shed additional light on the diversity, origins and relationships of the genus within this small island country.

Taxonomy

Aponogeton dassanayakei **Manawaduge & Yakandawala, *sp. nov.* (Fig. 6)**

Aponogeton dassanayakei is distinct from the other two proliferous species known in the genus by having the combination of characters; highly undulated long strictly submersed leaves with no alternately transparent or opaque patterns, broad white coloured persistent tepals and caducous spathe.

Type:—SRI LANKA. Western Province: Kalutara, Ittapana Thotupola-South End, (Ittapane–Horawala Thotupola Road), elev. 3 m, 08° 23.910′ N / 80° 4.067′ E, 15 February 2015, Manawaduge & Yakandawala 215. (Holotype: PDN!).

Tuber cylindrical and elongate; 9–20 mm Ø. **Submerged leaves** lamina; 17–56 × 1.4–5.2 cm; linear and slightly curved, apex acute and base cuneate, margin finely undulate, midrib with 6–8 parallel nerves; **Petioles** up to 56 cm long, brittle, bluntly triangular. **Floating leaves** absent. **Peduncle** up to 178 cm, widening towards the inflorescence. **Spathe** up to 35 mm, caduceus. **Inflorescence** with 1 spike; spike up to 15 cm, densely flowered; flowers turned towards all directions. **Tepals** 2, 1.2–2.3 × 1.3–2.5 mm, persistent, 1 nerved, white, broad. **Stamens** 6, 1–2 mm; filaments slightly widening towards the base, white, anthers grayish green. **Carpels** 3, white, 1.0–1.5 × 0.4–1 mm; ovules 2. **Infructescence** up to 31 cm. **Folicals** up to 10 × 6 mm, elongated, triangular, with rough coat and a short, terminal, curved beak. **Seeds** with a simple testa; embryo up to 8–9 × 3–6 mm, plumule attached near the base of the embryo and in a very wide groove. **Proliferous peduncles** ascending up to 45 cm, slightly thickened towards the tip.

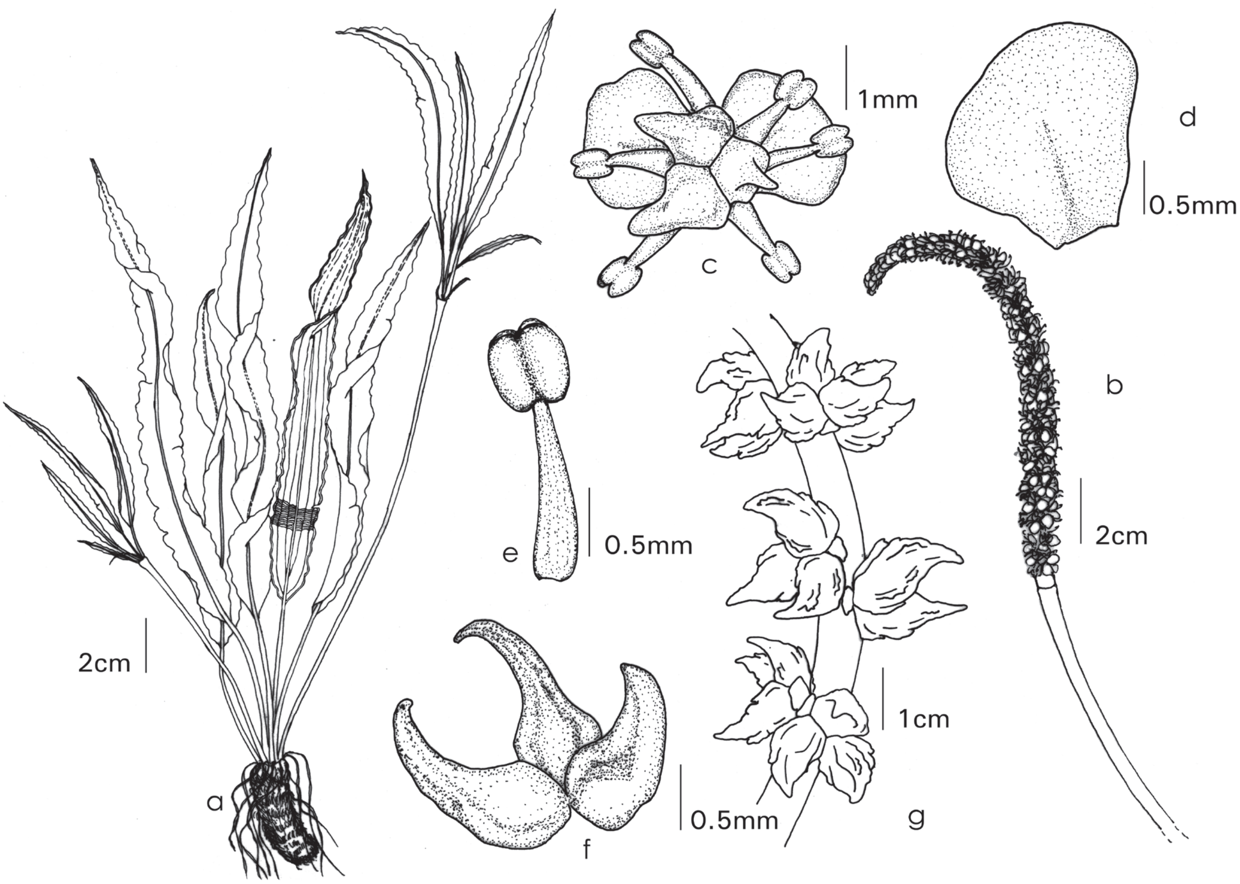

FIGURE 6. *Aponogeton dassanayakei* Manawaduge & Yakandawala (a) habit, (b) inflorescence, (c) floret, (d) tepal, (e) stamen, (f) gynoecium and (g) infructescence.

Phenology:—Throughout the year.

Distribution:—*Aponogeton dassanayakei* occurs in the low land wet zone, in slow flowing rivulets and rivers in much deeper water (below 1–2 m in some cases) and also in saline water towards the lagoons.

Eponymy:—The new species has been named after Professor M. D. Dassanayake, an eminent Plant Taxonomist in Sri Lanka and the General Editor of "A Revised Handbook to the Flora of Ceylon" (Vols. I–XV).

Additional specimens examined (Paratypes):—SRI LANKA. Western Province: Colombo, Hanwella, 06°54.109′ N, 80°05.613′ E, 13 m, 28 July 2014, Manawaduge & Yakandawala 105 (PDN!); Kalutara, Meegama, near Meegama Thotupola bridge, 06°24.825′N, 80°04.005′ E, 4 m , 11 August 2014, Manawaduge & Yakandawala 408, 409 (PDN!); Lunuganga, Bawa Gardens, 06°24. 254′N, 80°01.121′ E, 18 m, 11 August 2014, Manawaduge & Yakandawala 109 (PDN!); same locality, 06°24.30′N, 80° 1.211′E, 18 m, 15 February 2015, Manawaduge & Yakandawala 117 (PDN!); Bandaragama,Waskaduwa—Bandaragama road, 06°41.155 ′ N 79° 58. 857 ′E, 2 m, 11August 2014, Manawaduge & Yakandawala 110 (PDN!); Gampaha, Kirindiwita, Kirindiwita–Ganemulla road, 07° 5.370′N 79°58.156′E, 10 m, 24 September 2015, Manawaduge & Yakandawala 126 (PDN!); Yagoda, 07°4.390′N, 79°58.188′E, 10 m, 24 September 2015, Manawaduge & Yakandawala 127 (PDN!); Sabaragamuwa Province: Ratnapura, Kuruwuta, Colombo–Batticaloa highway, 06°46.982′N, 80°21.579′E, 27 m, 17 December 2015, Manawaduge & Yakandawala 128 (PDN!).

Acknowledgements

Financial assistance provided by the University of Peradeniya, Sri Lanka (University Research Grant RG/2014/38/S) to DY is gratefully acknowledged. Authors wish to thank The Department of Wildlife Conservation of Sri Lanka for granting permission for collecting of material, National Herbarium, Royal Botanical Gardens, Peradeniya, Sri Lanka and Menaka Ariyarathne and U. B. Priyadharshana for their assistance in the field.

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APPENDIX 1. List of *Aponogeton* taxa investigated in the study, their collection dates, localities, and voucher specimen information (all specimens deposited at The National Herbarium, Peradeniya, Sri Lanka).

Species	Collection Date	Province	Locality	Voucher Specimen
A. crispus	25/05/2014	Central	Naula (Matale)	*Manawaduge & Yakandawala 101*
	25/05/2014	Central	Pidurangala (Matale)	*Manawaduge & Yakandawala 102*
	25/05/2014	Central	Pidurangala (Matale)	*Manawaduge & Yakandawala 103*
	26/09/2014	Central	RBG (Peradeniya)	*Manawaduge & Yakandawala 111*
	13/06/2015	North Central	Tirappane (Anuradhapura)	*Manawaduge & Yakandawala 118*
	13/06/2015	North Central	Kebithigollewa (Anuradhapura)	*Manawaduge & Yakandawala 119*
	13/06/2015	North Central	TittagoneWewa (Anuradhapura)	*Manawaduge & Yakandawala 120*
A. natans	25/05/2014	Eastern	Batticaloa (Batticaloa)	*Manawaduge & Yakandawala 704,705,706*
	25/10/2014	North Central	Somawathiya (Polonnaruwa)	*Manawaduge & Yakandawala 113*
	14/06/2015	Northern	Muliyarkulam (Vavunia)	*Manawaduge & Yakandawala 121*
	14/06/2015	Northern	Murunkan (Mannar)	*Manawaduge & Yakandawala 122*
	14/06/2015	Northern	Murunkan (Mannar)	*Manawaduge & Yakandawala 123*
	06/12/2015	Eastern	Batticaloa (Batticaloa)	*Manawaduge & Yakandawala 627*
A. rigidifolius	28/07/2014	Southern	Kottawa (Galle)	*Manawaduge & Yakandawala 506,507*
	28/07/2014	Southern	Kanneliya (Galle)	*Manawaduge & Yakandawala 107*
	07/0/2015	southern	Sinharaja (Galle)	*Manawaduge & Yakandawala 114*
	15/02/2015	Southern	Wanduramba (Galle)	*Manawaduge & Yakandawala 315,316*
A. jacobsenii	13/10/2014	Central	Horton plains (N' Eliya)	*Manawaduge & Yakandawala 112*
	23/07/2015	Central	Horton plains (N' Eliya)	*Manawaduge & Yakandawala 124*
A. dassanayakei	28/07/2014	Western	Hanwella (Colombo)	*Manawaduge & Yakandawala 105*
	11/08/2014	Western	Meegama (Kalutara)	*Manawaduge & Yakandawala 408,409*
	11/08/2014	Western	Lunuganga (Kalutara)	*Manawaduge & Yakandawala 109*
	11/08/2014	Western	Delgoda (Kalutara)	*Manawaduge & Yakandawala 110*
	15/02/2015	Western	Ittapane (Kalutara)	*Manawaduge & Yakandawala 215,216,217*
	15/02/2015	Western	Lunuganga (Kalutara)	*Manawaduge &Yakandawala 117*
	24/09/2015	Western	Ganemulla (Gampaha)	*Manawaduge & Yakandawala 126*
	24/09/2015	Western	Yagoda (Gampaha)	*Manawaduge & Yakandawala 127*
	17/12/2015	Sabaragamuwa	Kuruwita (Ratnapura)	*Manawaduge & Yakandawala 128*

APPENDIX 2. Morphological data matrix used in the morphometric analysis. Character numbers correspond to that of Table 2. Acronyms assigned to OTUs correspond to that of Table 1. ? = missing data.

oOTUs	Character																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
A1	1	1	1	2	1	2.8	1.8	13.0	0.3	0	12.0	3.8	1	0	0	2	1	0	4	63.0	0.2	0	15.0	3.0	0	0	0	4	1	1
A2	1	1	1	2	1	3.5	1.2	22.0	0.5	0	20.0	5.7	1	0	0	2	1	0	4	71.0	0.3	0	17.0	4.0	0	0	0	4	1	1
B3	1	1	1	2	1	1.7	1.0	35.0	0.3	0	11.5	3.0	1	0	0	2	1	0	4	?	?	?	?	?	0	0	0	4	1	1
B4	1	1	1	2	1	1.3	0.7	38.0	0.4	0	18.0	4.0	1	0	0	2	1	0	4	17.0	0.2	0	6.0	2.0	0	0	0	4	1	1
C5	1	1	1	2	1	2.8	1.8	11.0	0.5	0	18.0	5.0	1	0	0	2	1	0	5	32.0	0.3	0	15.0	2.0	0	0	0	4	1	1
C6	1	1	1	2	1	1.0	0.8	9.8	0.6	0	21.0	6.1	1	0	0	2	1	0	5	35.0	0.3	0	18.0	2.0	0	0	0	4	1	1
D7	0	1	2	2	1	2.5	1.5	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	32.0	0.6	1	14.0	3.0	0	1	1	4	2	1
D8	0	1	2	2	1	2.0	1.5	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	33.0	0.6	1	13.0	3.0	0	1	1	4	2	1
D9	0	1	2	2	1	1.5	1.0	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	26.0	0.5	1	11.0	3.0	0	1	1	4	2	1
E10	1	0	0	2	2	4.0	0.9	23.0	0.4	0	31.0	1.4	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
E11	1	0	0	2	2	10.0	1.2	25.0	0.5	0	43.0	2.4	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
F12	1	0	0	1	0	6.0	0.8	56.0	0.3	0	59.0	4.1	2	2	0	0	0	2	5	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
F13	1	0	0	1	0	6.0	0.8	42.0	0.4	0	51.0	5.0	2	2	0	0	0	2	5	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
F14	1	0	0	1	0	4.0	0.3	13.0	0.3	0	28.0	3.0	2	2	0	0	0	2	5	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
G15	1	0	0	1	0	10.0	0.8	18.0	0.4	0	33.0	2.0	2	2	0	0	0	2	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
G16	1	0	0	1	0	5.0	0.6	11.0	0.3	0	19.0	3.0	2	2	0	0	0	2	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1

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APPENDIX 2. (Continued)

oOTUs	Character																												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
G17	1	0	0	1	0	6.0	0.8	16.0	0.3	0	30.0	3.0	2	2	0	0	0	2	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
H18	1	0	0	2	2	6.0	2.0	20.0	0.6	0	43.0	3.7	1	3	1	0	0	0	3	0.0	5.0	2	0.0	0.0	2	3	3	0	3	0
H19	1	0	0	2	2	6.0	2.0	32.0	0.8	0	56.0	4.9	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	0
H20	1	0	0	2	2	7.0	2.0	21.0	0.6	0	55.0	5.2	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	0
I21	1	0	0	2	2	4.0	2.0	13.0	0.5	0	25.0	3.2	1	3	1	0	0	0	3	0.0	0.0	2	0.0	0.0	2	3	3	0	3	0
I22	1	0	0	2	2	3.0	1.0	8.0	0.4	0	17.0	2.5	1	3	1	0	0	0	3	0.0	0.0	2	0.0	0.0	2	3	3	0	3	0
I23	1	0	0	2	2	5.0	2.0	15.0	0.7	0	28.0	4.6	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	0
J24	1	0	0	2	2	2.0	2.0	50.0	0.5	0	51.0	4.7	1	3	1	0	0	0	3	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
J25	1	0	0	2	2	3.0	1.0	40.0	0.7	0	59.0	4.5	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
J26	1	0	0	2	2	3.0	2.0	25.0	0.4	0	39.0	2.5	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	0
K27	1	1	1	2	1	?	?	33.3	0.5	0	25.0	9.0	1	0	0	2	1	0	4	71.0	0.3	0	13.0	3.8	0	0	0	5	1	1
L28	1	0	0	2	2	5.0	2.0	18.0	0.5	0	19.0	7.0	1	1	0	1	1	1	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
L29	1	0	0	2	2	4.0	1.9	10.0	0.5	0	8.0	3.6	1	1	0	1	1	1	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
L30	1	0	0	2	2	5.0	4.0	5.3	0.5	0	7.0	3.1	1	1	0	1	1	1	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
M31	0	1	2	2	1	4.5	0.9	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	4.8	0.2	1	5.0	0.6	0	1	1	4	2	1
M32	0	1	2	2	1	4.0	1.5	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	4.0	0.2	1	4.0	0.5	0	1	1	4	2	1
M33	0	1	2	2	1	4.8	1.5	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	5.7	0.3	1	5.5	0.5	0	1	1	4	2	1
M34	0	1	2	2	1	1.5	0.8	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	12.3	0.3	1	7.6	0.8	0	1	1	4	2	1
M35	0	1	2	2	1	2.5	1.5	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	12.5	0.2	1	7.5	1.3	0	1	1	4	2	1

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APPENDIX 2. (Continued)

oOTUs	Character																												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
M36	0	1	2	2	1	3.0	1.2	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	12.3	0.2	1	7.3	1.0	0	1	1	4	2	1
M37	0	1	2	2	1	3.5	1.8	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	21.7	0.4	1	9.2	1.5	0	1	1	4	2	1
M38	0	1	2	2	1	4.0	1.2	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	22.0	0.3	1	9.6	1.2	0	1	1	4	2	1
M39	0	1	2	2	1	1.5	0.8	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	28.8	0.3	1	11.2	1.7	0	1	1	4	2	1
M40	0	1	2	2	1	2.0	1.2	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	28.7	0.3	1	10.2	2.0	0	1	1	4	2	1
N41	1	0	0	1	0	14.0	0.8	22.0	0.4	0	38.0	3.1	2	2	0	0	0	2	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
N42	1	0	0	1	0	10.0	0.7	25.0	0.3	0	40.0	3.5	2	2	0	0	0	2	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
O43	1	0	0	1	0	6.0	0.8	15.0	0.3	0	29.0	2.5	2	2	0	0	0	2	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
O44	1	0	0	1	0	8.0	0.6	17.0	0.3	0	32.0	3.0	2	2	0	0	0	2	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
P45	1	0	0	2	2	4.0	1.0	40.0	0.4	0	25.0	4.5	1	3	1	0	0	0	3	0.0	0.0	2	0.0	0.0	2	3	3	0	3	0
P46	1	0	0	2	2	4.0	2.0	35.0	0.6	0	39.0	4.0	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	0
Q47	1	0	0	2	2	3.0	1.0	31.0	0.5	0	40.0	3.5	1	3	1	0	0	0	3	0.0	0.0	2	0.0	0.0	2	3	3	0	3	0
Q48	1	0	0	2	2	3.0	2.0	25.0	0.5	0	45.0	3.0	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	0
R49	1	1	1	2	1	1.7	1.5	25.0	0.3	0	26.0	4.5	1	0	0	2	1	0	4	50.0	0.2	0	16.0	3.0	0	0	0	4	1	1
R50	1	1	1	2	1	3.0	2.8	22.0	0.4	0	21.0	4.0	1	0	0	2	1	0	4	45.0	0.3	0	15.0	2.8	0	0	0	4	1	1
S51	1	1	1	2	1	1.3	1.1	11.0	0.5	0	10.0	5.0	1	0	0	2	1	0	4	35.0	0.3	0	14.0	2.9	0	0	0	4	1	1
S52	1	1	1	2	1	2.8	2.5	19.0	0.3	0	15.0	5.7	1	0	0	2	1	0	4	39.0	0.2	0	13.0	2.2	0	0	0	4	1	1
T53	1	1	1	2	1	1.4	1.3	19.0	0.3	0	12.0	3.5	1	0	0	2	1	0	5	28.0	0.2	0	11.0	2.5	0	0	0	4	1	1
T54	1	1	1	2	1	1.7	1.5	21.0	0.4	0	19.0	5.5	1	0	0	2	1	0	5	29.0	0.3	0	10.0	3.0	0	0	0	4	1	1

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APPENDIX 2. (Continued)

oOTUs	Character																												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
U55	0	1	2	2	1	3.0	2.3	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	34.0	0.6	1	12.0	3.0	0	1	1	4	2	1
U56	0	1	2	2	1	2.0	1.5	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	25.0	0.6	1	16.0	2.0	0	1	1	4	2	1
V57	0	1	2	2	1	1.9	1.5	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	28.0	0.3	1	15.0	2.0	0	1	1	4	2	1
V58	0	1	2	2	1	2.2	1.8	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	31.0	0.5	1	13.0	3.0	0	1	1	4	2	1
W59	0	1	2	2	1	3.5	2.0	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	34.0	0.6	1	15.0	3.0	0	1	1	4	2	1
W60	0	1	2	2	1	1.8	1.2	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	33.0	0.6	1	10.0	3.0	0	1	1	4	2	1
X61	1	0	0	2	2	5.0	2.0	10.0	0.6	0	15.0	5.0	1	1	0	1	1	1	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
X62	1	0	0	2	2	4.0	3.0	15.0	0.5	0	10.0	6.0	1	1	0	1	1	1	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
Y63	1	0	0	2	2	6.0	2.0	50.0	0.5	0	49.0	3.6	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
Y64	1	0	0	2	2	7.0	1.0	41.0	0.6	0	54.0	2.9	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
Z65	1	0	0	2	2	5.0	2.0	30.0	0.5	0	41.0	3.5	1	3	1	0	0	0	3	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
Z66	1	0	0	2	2	4.0	1.5	32.0	0.5	0	39.0	3.5	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
AA67	0	1	2	2	1	2.0	1.8	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	28.0	0.4	1	15.0	3.0	0	1	1	4	2	1
AA68	0	1	2	2	1	3.0	1.5	0.0	0.0	2	0.0	0.0	3	4	2	3	2	3	0	27.0	0.5	1	12.0	3.0	0	1	1	4	2	1
AB69	1	0	0	2	2	4.0	2.0	30.0	0.5	0	39.0	3.5	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1
AB70	1	0	0	2	2	3.0	1.5	25.0	0.5	0	40.0	3.5	1	3	1	0	0	0	4	0.0	0.0	2	0.0	0.0	2	3	3	0	3	1

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APPENDIX 2. (Continued)

oOTUs	Character																													
	31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**
A1	0	68	0	17	0.7	2	2	1	1.75	1.55	1.13	1	6	1	1.75	0	3	1.70	1.20	1	2	0	0	1	0	0	0	8.30	3.32	1	0
A2	0	77	0	15	0.6	2	2	1	1.55	1.25	1.24	1	6	1	1.50	0	3	1.70	1.25	1	2	0	0	1	0	0	0	8.72	3.74	1	0
B3	0	59	0	11	0.5	0	2	1	1.25	1.05	1.19	1	6	1	1.30	0	3	1.00	0.50	1	2	0	0	1	0	0	0	7.72	3.40	1	0
B4	0	70	0	10	0.4	0	2	1	1.60	1.50	1.07	1	6	1	1.65	0	3	1.10	0.50	1	2	0	0	1	0	0	0	7.55	3.49	1	0
C5	0	45	0	8	0.5	0	2	1	2.10	2.00	1.05	1	6	1	2.15	0	3	1.50	1.10	1	2	0	0	1	0	0	0	7.89	3.57	1	0
C6	0	40	0	11	0.5	0	2	1	2.00	1.90	1.05	1	6	1	2.05	0	3	1.60	1.20	1	2	0	0	1	0	0	0	7.64	3.49	1	0
D7	1	20	0	10	1.0	2	2	2	3.00	1.90	1.58	1	6	0	4.15	1	3	4.00	1.55	3	8	1	1	2	1	1	1	1.80	0.55	0	2
D8	1	30	0	11	0.8	2	2	2	2.85	1.60	1.78	1	6	0	3.00	1	3	3.60	1.50	3	8	1	1	2	1	1	1	1.60	0.55	0	2
D9	1	15	0	15	0.7	2	2	2	2.90	1.75	1.66	1	6	0	2.60	1	3	3.50	1.50	3	8	1	1	2	1	1	1	1.50	0.50	0	2
E10	0	63	0	16	0.5	0	2	0	1.25	1.50	0.83	1	6	1	1.08	2	3	1.05	0.63	0	2	0	0	1	0	0	1	6.64	2.99	1	0
E11	0	64	0	15	0.4	0	2	0	1.75	1.88	0.93	1	6	1	1.48	2	3	1.45	0.08	0	2	0	0	1	0	0	1	8.00	2.00	1	0
F12	0	40	0	18	0.5	2	2	0	1.50	1.38	1.09	1	6	1	2.00	0	3	1.50	0.08	0	2	0	0	1	0	0	1	10.00	3.00	1	0
F13	0	42	0	11	0.6	2	2	0	2.50	1.38	1.81	1	6	1	2.30	0	3	1.63	0.88	0	2	0	0	1	0	0	1	12.00	4.00	1	0
F14	0	34	0	8	0.5	2	2	0	2.55	1.40	1.82	1	6	1	2.25	0	3	1.70	0.90	0	2	0	0	1	0	0	1	9.00	3.00	1	0
G15	0	70	0	13	0.9	1	2	0	1.65	1.13	1.46	1	6	1	1.75	3	3	2.50	1.00	0	2	0	0	1	0	0	1	12.00	4.00	1	0
G16	0	93	0	43	0.9	1	2	0	1.70	1.20	1.42	1	6	1	1.98	3	3	2.55	1.05	0	2	0	0	1	0	0	1	12.00	4.00	1	0
G17	0	62	0	17	0.7	1	2	0	1.65	1.15	1.43	1	6	1	1.88	3	3	2.50	1.05	0	2	0	0	1	0	0	1	10.00	4.00	1	0
H18	0	178	0	14	0.8	2	2	0	1.33	1.40	0.95	1	6	1	1.50	2	3	1.10	0.63	0	2	0	0	1	0	0	1	9.96	0.87	1	0

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APPENDIX 2. (Continued)

oOTUs	Character																													
	31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**
H19	0	138	0	17	0.8	2	2	0	1.33	1.43	0.93	1	6	1	1.48	2	3	1.15	0.65	0	2	0	0	1	0	0	1	8.50	0.78	1	0
H20	0	163	0	31	0.5	2	2	0	1.25	1.33	0.94	1	6	1	1.38	2	3	1.08	0.63	0	2	0	0	1	0	0	1	0.95	0.89	1	0
I21	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	2	?	?	1	0	?	1	?	?	?	?
I22	0	53	0	6	0.5	2	2	0	1.53	1.88	0.81	1	6	1	1.78	2	3	1.43	0.83	0	2	0	0	1	0	0	1	7.50	0.68	1	0
I23	0	99	1	4	0.5	2	2	0	2.33	2.50	0.93	1	6	1	2.03	2	3	1.50	1.00	0	2	0	0	1	0	0	1	0.83	0.75	1	0
J24	0	136	0	14	0.9	2	2	0	1.13	1.30	0.87	1	6	1	1.23	2	3	0.98	0.38	0	2	0	0	1	0	0	1	7.14	0.65	1	0
J25	0	135	0	27	0.8	2	2	0	1.40	1.45	0.97	1	6	1	1.43	2	3	1.20	0.50	0	2	0	0	1	0	0	1	7.74	0.68	1	0
J26	0	156	0	29	0.8	2	2	0	1.25	1.28	0.98	1	6	1	1.30	2	3	1.00	0.45	0	2	0	0	1	0	0	1	8.50	0.75	1	0
K27	0	80	0	11	0.6	1	2	1	1.60	1.50	1.07	1	6	1	1.00	0	3	1.50	0.80	1	2	0	0	1	0	0	0	8.80	4.00	1	0
L28	1	53	0	11	0.7	2	2	0	1.75	2.50	0.70	1	6	2	1.40	1	3	2.25	1.00	2	2	2	0	1	0	0	1	13.00	11.00	1	1
L29	1	55	0	8	0.6	2	2	0	1.75	2.65	0.66	1	6	2	1.40	1	3	2.15	0.95	2	2	2	0	1	0	0	1	12.00	10.00	1	1
L30	1	50	0	5	8.0	2	2	0	1.70	2.25	0.76	1	6	2	1.35	1	3	2.00	0.85	2	2	2	0	1	0	0	1	10.00	8.00	1	1
M31	1	12.5	0	4	0.5	2	2	2	1.75	1.05	1.67	1	6	0	1.75	1	3	2.50	1.25	3	8	1	1	2	1	1	1	1.15	0.50	0	2
M32	1	12.8	0	3.3	0.5	2	2	2	1.80	1.20	1.50	1	6	0	2.20	1	3	2.55	1.30	3	8	1	1	2	1	1	1	1.10	0.50	0	2
M33	1	14	0	5.25	0.5	2	2	2	1.70	1.10	1.55	1	6	0	2.00	1	3	2.50	1.20	3	8	1	1	2	1	1	1	1.15	0.50	0	2
M34	1	23	0	4.5	0.5	2	2	2	1.90	1.00	1.90	1	6	0	2.10	1	3	2.00	1.20	3	8	1	1	2	1	1	1	1.60	0.50	0	2
M35	1	23	0	12	0.6	2	2	2	1.95	1.10	1.77	1	6	0	2.20	1	3	2.50	12.00	3	8	1	1	2	1	1	1	1.65	0.50	0	2

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APPENDIX 2. (Continued)

oOTUs	Character																													
	31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**
M36	1	22.5	0	7.5	0.6	2	2	2	1.90	1.15	1.65	1	6	0	2.15	1	3	2.00	1.00	3	8	1	1	2	1	1	1	1.65	0.60	0	2
M37	1	34	0	12	0.8	2	2	2	2.15	1.25	1.72	1	6	0	2.85	1	3	2.50	1.20	3	8	1	1	2	1	1	1	1.75	0.60	0	2
M38	1	27	0	9	0.8	2	2	2	2.20	1.30	1.69	1	6	0	2.90	1	3	2.55	1.30	3	8	1	1	2	1	1	1	1.70	0.65	0	2
M39	1	28	0	9.5	0.6	2	2	2	2.30	1.30	1.77	1	6	0	3.05	1	3	1.20	1.25	3	8	1	1	2	1	1	1	1.80	0.60	0	2
M40	1	38	0	8	0.6	2	2	2	2.20	1.20	1.83	1	6	0	2.90	1	3	2.50	1.25	3	8	1	1	2	1	1	1	1.75	0.60	0	2
N41	0	56	0	15	0.7	1	2	0	1.65	1.13	1.46	1	6	1	1.88	0	3	1.63	0.88	0	2	0	0	1	0	0	1	9.00	3.00	1	0
N42	0	50	0	10	0.5	2	2	0	2.50	1.40	1.79	1	6	1	2.25	0	3	1.70	0.88	0	2	0	0	1	0	0	1	10.00	4.00	1	0
O43	0	45	0	12	0.6	1	2	0	1.70	1.30	1.31	1	6	1	1.75	3	3	2.55	1.05	0	2	0	0	1	0	0	1	12.00	4.00	1	0
O44	0	42	0	10	0.5	1	2	0	1.65	1.20	1.38	1	6	1	1.98	3	3	2.50	1.05	0	2	0	0	1	0	0	1	10.00	4.00	1	0
P45	0	150	0	20	0.8	2	2	0	1.55	1.60	0.97	1	6	1	1.60	2	3	1.20	0.38	0	2	0	0	1	0	0	1	9.00	0.60	1	0
P46	0	145	0	11	0.6	2	2	0	1.33	1.40	0.95	1	6	1	1.40	2	3	1.50	0.40	0	2	0	0	1	0	0	1	7.50	0.60	1	0
Q47	0	155	0	16	0.7	2	2	0	2.33	2.40	0.97	1	6	1	2.40	2	3	1.43	0.60	0	2	0	0	1	0	0	1	8.80	0.68	1	0
Q48	0	146	0	15	0.6	2	2	0	1.55	1.60	0.97	1	6	1	1.60	2	3	1.08	0.50	0	2	0	0	1	0	0	1	8.50	0.70	1	0
R49	0	65	0	15	0.5	0	2	0	1.55	1.25	1.24	1	6	1	1.55	0	3	1.70	1.20	1	2	0	0	1	0	0	0	8.70	3.50	1	0
R50	0	56	0	16	0.6	0	2	0	1.75	1.55	1.13	1	6	1	1.75	0	3	1.70	1.20	1	2	0	0	1	0	0	0	7.80	3.20	1	0
S51	0	40	0	18	0.7	0	2	1	1.50	1.20	1.25	1	6	1	1.55	0	3	1.50	0.50	1	2	0	0	1	0	0	0	8.80	3.75	1	0
S52	0	46	0	13	0.5	0	2	1	1.60	1.30	1.23	1	6	1	1.65	0	3	1.60	0.80	1	2	0	0	1	0	0	0	7.50	3.40	1	0

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APPENDIX 2. (Continued)

oOTUs	Character																													
	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
T53	0	58	0	12	0.5	0	2	1	1.70	1.50	1.13	1	6	1	1.75	0	3	1.50	0.90	1	2	0	0	1	0	0	0	7.09	3.50	1	0
T54	0	43	0	11	0.6	0	2	1	1.50	1.40	1.07	1	6	1	1.55	0	3	1.50	0.80	1	2	0	0	1	0	0	0	8.20	3.50	1	0
U55	1	25	0	15	0.8	2	2	2	2.50	1.50	1.67	1	6	0	3.00	1	3	3.50	1.55	3	8	1	1	2	1	1	1	1.80	0.55	0	2
U56	1	30	0	11	0.5	2	2	2	2.90	1.80	1.61	1	6	0	2.90	1	3	3.40	1.60	3	8	1	1	2	1	1	1	1.50	0.50	0	2
V57	1	15	0	9	0.6	2	2	2	2.10	1.30	1.62	1	6	0	3.40	1	3	3.80	1.50	3	8	1	1	2	1	1	1	1.70	0.55	0	2
V58	1	20	0	8	0.6	2	2	2	2.60	1.60	1.63	1	6	0	4.00	1	3	3.90	1.60	3	8	1	1	2	1	1	1	1.90	0.55	0	2
W59	1	28	0	13	0.7	2	2	2	1.90	1.10	1.73	1	6	0	3.10	1	3	3.50	1.50	3	8	1	1	2	1	1	1	1.70	0.55	0	2
W60	1	35	0	10	0.8	2	2	2	2.50	1.50	1.67	1	6	0	4.00	1	3	3.80	1.50	3	8	1	1	2	1	1	1	1.60	0.50	0	2
X61	1	55	0	7	0.7	2	2	0	1.75	2.25	0.78	1	6	2	1.40	1	3	2.25	0.95	2	2	2	0	1	0	0	1	12.00	10.00	1	1
X62	1	53	0	6	0.8	2	2	0	1.70	2.50	0.68	1	6	2	1.35	1	3	2.10	0.85	2	2	2	0	1	0	0	1	10.00	9.00	1	1
Y63	0	98	0	14	0.8	2	2	0	1.33	1.43	0.93	1	6	1	1.50	2	3	1.50	0.60	0	2	0	0	1	0	0	1	9.00	0.60	1	0
Y64	0	80	0	10	0.9	2	2	0	1.40	1.55	0.90	1	6	1	1.40	2	3	1.20	0.60	0	2	0	0	1	0	0	1	6.20	0.50	1	0
Z65	0	59	0	16	0.7	2	2	0	1.30	1.50	0.87	1	6	1	1.70	2	3	1.10	0.50	0	2	0	0	1	0	0	1	7.10	0.60	1	0
Z66	0	151	0	15	0.8	2	2	0	1.50	1.65	0.91	1	6	1	1.60	2	3	1.00	0.50	0	2	0	0	1	0	0	1	5.80	0.50	1	0
AA67	1	28	0	15	0.8	2	2	2	1.90	1.10	1.73	1	6	0	2.10	1	3	3.30	1.30	3	8	1	1	2	1	1	1	1.50	0.50	0	2
AA68	1	30	0	13	0.7	2	2	2	2.00	1.30	1.54	1	6	0	2.00	1	3	3.50	1.50	3	8	1	1	2	1	1	1	1.70	0.60	0	2
AB69	0	80	0	10	0.8	2	2	0	1.50	1.70	0.88	1	6	1	1.60	2	3	1.30	0.50	0	2	0	0	1	0	0	1	6.20	0.50	1	0
AB70	0	75	0	15	0.6	2	2	0	1.30	1.40	0.93	1	6	1	1.70	2	3	1.20	0.60	0	2	0	0	1	0	0	1	7.70	0.60	1	0