Developing an English Zoology Academic Word List: A Corpus-Based Study

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Abstract

This study aimed to (1) generate a list of common vocabulary used in zoology research articles and (2) validate the word lists with zoology experts. The Zoology Research Articles Corpus (ZRAC) was compiled from 268 zoology research articles published between January 2016 and February 2019 from the International Journal of Zoology by the Zoological Society of London. AntWordProfiler (v1.4.0) (Anthony, 2013) software was used to analyse the frequency of the 1,530,384 words comprising the ZRAC. The software identified 504 frequently used words generally related to zoology. Seven university zoology lecturers were asked to clarify the specification of the words in the field of zoology. This validation process resulted in the removal of 218 words (43.25%), as they were not specifically related to the field of zoology. The list was then categorized into word families. The word list was generated using Coxhead's range and word frequency criteria, and called the Zoology Academic Word Lists (ZAWL). The ZAWL aims to assist undergraduate and graduate students in their preparation for the reading and writing of research papers in zoology. Additionally, ZAWL can be applied in vocabulary pedagogy for lecturers in selecting appropriate vocabulary to teach undergraduate and graduate classes.

Keywords: zoology academic word list, zoology research articles, corpus-based study

1. Introduction

Requirements for mastering English as an International Language (EIL) have increased significantly in recent years. One of the most significant requirements for students who are studying English as a Foreign Language (EFL) and English as a Second Language (ESL) is to read academic texts in English. The use of academic texts has become the focus of a number of recent corpus-based studies, especially as this priority has placed increased demands on teachers of English for Academic Purposes (EAP) and English for Specific Purposes (ESP) to develop materials that are specifically beneficial to learners in different academic fields. Researchers, therefore, have investigated academic articles to develop vocabulary lists that have specific and distinguishing features.

The acquisition of academic vocabulary is an important measure of learners' academic competence (Phyllis, 1996). In addition, as stated by Corson (1997), knowledge of academic vocabulary is critical to success in both reading academic texts and appropriate, effective writing in specific areas of study. Acquiring specialized academic vocabulary, however, is extremely challenging for EFL and ESL learners, since these words are used less frequently than other vocabulary in general academic texts. Therefore, the emphasis that is used to study specialized vocabulary used in academic texts falls on academic corpora. More precisely, word analysis from these texts has revealed that some particular words appear with a much higher frequency in some academic texts in comparison to others (Coxhead, 2000). This makes studying and making word lists necessary. Regarding EAP, researchers have focused on academic vocabulary and developed several useful word lists. Advances in computer science and accessibility of corpora and corpus analysis software has made the task of creating word lists based on frequency of general and specialized corpora feasible for individual researchers and teachers of ESP (Nation, 2016).

Nation (2001) suggested that one of the benefits of academic word lists for specific teaching and learning disciplines is that they provide a useful guide for teachers to assist them in lesson planning and developing instructional materials to include identified vocabulary. Researchers have recently developed word lists containing high frequency words for students of specialized lexical needs. Word lists were also explored in terms of frequency and coverage with General Service List (GSL) by West (1953) to find discipline specificity. For instance, Wang *et al.* (2008) developed the Medical Academic Word List (MAWL) including 623 non-GSL word families that occurred in research articles in the medical field. Because students of different disciplines are required to learn different vocabulary, word lists that meet the specific needs of those students are in demand. In other words, to develop academic word lists for a specialized area is beneficial to overall learning outcomes of that area (Ward, 2009).

2. Literature Review

The Role of Vocabulary in Language Learning

The findings of several research studies in second language acquisition (i.e. Chen, 2011; Qian, 2002; Zhang & Zhang, 2020) show that reading proficiency can be forecast based on learners' vocabulary knowledge. A principal difficulty EFL learners encounter is the preponderance of unfamiliar and unknown words in their reading materials. Vocabulary acquisition plays a significant role in language reading skills development in the target language (Moghadam et al., 2012). L2 learners must expand their reading skills to read texts more effectively (Nation, 2006).

Researchers have investigated the relationship between L2 vocabulary knowledge and reading comprehension. Laufer and Ravenhorst - Kalovski (2010) argued that 95% running words are needed for reasonable comprehension of a text. If a reader's lexical threshold is below 95%, then the reader will likely be unable to effectively read and comprehend the text without external assistance. Sheng and McGregor (2010) also argued that vocabulary acquisition is the foundation of language learning. As there is a strong relationship between vocabulary knowledge and reading comprehension, building word lists is a vital step to enhance reading abilities (Kumar et al., 2013).

Nation (2001) classified vocabulary into four groups: high-frequency words, academic words, technical words, and low-frequency words. High-frequency words occur with the greatest regularity in printed texts. Such words include both content words and function words. The most utilized list of high-frequency words is the General Service List (GSL) developed by Michael West's in 1953, which is composed of approximately 2,000 word families. The first 1,000 highest frequency words cover up to 75% of general English texts. The second kind of vocabulary, i.e. academic vocabulary, is extracted from different types of academic texts, e.g. linguistics, politics, business, etc. One of the most well-known academic word lists, i.e. the Academic Word List (AWL), was proposed by Averil Coxhead in 2000. The AWL includes 570 word families covering around 10% of academic texts. This grouping of words is appropriate for students in a general academic setting.

The next group concerns technical words that differ according to subject areas. These groups of words are developed by limiting the range of topics or language investigated systematically. Hence, specialized vocabulary lists for public speaking, reading academic texts, reading newspapers, or reading children's stories are likely to be developed. Both academic and technical words are known as specialized words. In contrast, low-frequency words include a large group of words that appear infrequently. Low-frequency words make up a small fraction of words in academic texts. They exclude high-frequency words, academic words, and technical words in a specific discipline. Moreover, proper names are considered low-frequency words.

Word Frequency Lists

A word frequency list, or word list, is usually sorted either in frequency order or in alphabetical order of all words in a specified corpus together with the frequency of word occurrence in the corpus. According to Chung and Nation (2003), a word list is useful in various linguistic studies, for example, stylistics, content analysis, language teaching, forensic linguistics, and information retrieval. They provide frequency information of the vocabulary in particular texts.

Word lists play an essential role in lexical studies, which aim to provide information on the frequency with which words occur in particular areas (Vongpumivitch et al., 2009). Generated word frequency lists allow teachers or course designers to determine which words are meaningful for their students and which can be dismissed. Each of the many word frequency lists in existence offer particular advantages according to the objectives of the list creator.

There are many well-known corpus-related studies introducing basic vocabulary items which are useful for pedagogical purposes (Ohashi & Katagiri, 2020). Following are two examples of well-known word lists: the General Service List (GSL) and the Academic Word List (AWL). GSL was created by Michael West in 1953. It contains 2,000 high-frequency English word families. It is useful especially for beginners since it is the source of the most frequently used words of the language. AWL is a list of 570 word families based on a 3.5 million-word corpus consisting of academic texts from journals, textbooks, and course books. It was developed and validated by Averil Coxhead and covers 28 subjects in the four major areas of art, science, commerce and law. The list excludes words that are in the GSL by West (1953).

A number of researchers have attempted to develop word lists that are specific to a subject, aimed at meeting the needs of the learners in their academic area. There has similarly been growing interest on the part of university science lecturers and students to read or write scientific articles in English. To consider more studies and research papers on science and technology published in English, English for Science and Technology (EST) has been developed and differentiated from general modern English into categories with characteristics unique to science and technology (Li & Li, 2015). Researchers have also been developing some word lists for specific scientific disciplines. There are, for example, Medical Word list (Hsu, 2013), Agriculture Word List (Martínez et al., 2009), Chemistry Academic Word List (Valipouri & Nassaji, 2013), Microbiology Academic Word list (Boonyos, 2014), Environmental Academic Word List (Liu & Han, 2015), and Food Science and Technology Academic Word List (Esfandiari & Moein, 2015).

One of the biological sciences sub-branches that has received interest is zoology, that is, the study of animal life covering subject matter ranging from the structure of organisms to the cellular unit of life. The field of zoology has

become an important academic department and study major for science students in higher education. Like others, zoology students are expected to be able to read and write their study and discovery in English in order to facilitate sharing with worldwide science communities. Because this particular discipline incorporates a wide range of specialties, acquiring a solid command of specialized vocabulary is likely to prove difficult for students, albeit invaluable for their reading and writing in English.

Numerous studies on word lists have been conducted; however, only a few studies sought to identify and extract zoology-specific vocabulary from English research articles. This study, therefore, fulfils this insufficiency, explores word-list establishing of field-specific academic word lists, and perhaps establishes a first zoology academic word list for university students to understand research articles in this particular discipline.

The present study was therefore aimed at answering the following research questions:

1. What words are commonly used in zoology research articles?
2. What are the opinions of zoology experts towards Zoology Word Lists?

3. Methodology

Due to the up-to-date and rigorous characteristics of research articles in the zoology field, a Zoology Research Article Corpus, hereafter ZRAC, was compiled through the following steps. First and foremost, in order to represent the word samples in compiling the ZRAC, the researchers consulted two zoology professors who work at one of the oldest, reputed public universities of Thailand. They recommended the international zoology and conservation science publications of the Zoological Society of London, many of which are regularly assigned to students. The research articles were then downloaded from https://zslpublications.onlinelibrary.wiley.com/journal/. In total, all of 268 zoology research articles published from January 2016 through February 2019 were included. The reason for choosing this period is that this study was conducted in 2019 and compiling the articles from the last three years could yield up-to-date corpus. All the selected zoology research articles were in portable document format (PDF), which were then converted into text files (*.txt.), in order to be processed by AntWordProfiler. To facilitate the analysis, figures, tables, bibliographies, footnotes, acknowledgments, references and appendices in the articles were removed from all the downloaded articles.

AntWordProfiler version 1.4.0, i.e. the latest version, was used to determine the number of occurrences of each word. AntWordProfiler is freeware for corpus linguistic research and data-driven learning created by Laurence Anthony (2013). AntWordProfiler is composed of a vocabulary profiling tool and File Viewer and Editor Tool. The profiling tool can generate statistics on

vocabulary and information on frequency related to a corpus of texts compiled into the program. Moreover, it can compare the corpus text files against vocabulary level lists based on the research of Paul Nation. The latest version of AntWordProfiler is 1.4W (2013). The program was used to identify the frequency of each word in the compiled ZRAC, while omitting those words included in the AWL and GSL. Function words were also removed during this procedure, since the focus was on content words for their core meaning and not grammar patterns.

In order to create the Zoology Academic Word List that represents words frequently found in the compiled zoology research articles, the same frequency of word family members as utilized by Coxhead's Academic Word List (AWL) was employed. Concerning the frequency of a word, many corpus-related studies (e.g. It-ngam & Phoocharoensilp, 2019; Liu & Han, 2015; Valipouri & Nassaji, 2013) including this present study adopted the same criteria as in AWL (Coxhead, 2000). To elaborate, this means with the frequency of 100 times in the whole AWL corpus of 3.5 million tokens, roughly 28.6 times in every one million words. This can be applied to this current corpus with the whole corpus size of 1.5 million running words, the cut-off frequency rate of this study was rounded up to 50 times (28.6 x 1.5 = 42.9). The comparison is shown in Table 1:

Table 1 Corpus Domain of AWL (Coxhead, 2000) and ZAWL

Criteria	AWL (Coxhead, 2000)	ZAWL
Corpus size	3.5 million tokens	1.5 million tokens
Special occurrences	Excluding West's (1953) GSL	Excluding West's (1953) GSL, Coxhead's (2000) AWL
Frequency	100 times on the whole corpus	50 times on the whole corpus

In the process of collecting the words after the ZRAC was compiled, only a headword, all its inflections and derivations were counted as a word family regarding the normalization of word forms. For instance, the word *compete* and other forms such as *competes, competed, competitive, competition* and *competitions* were counted as one word. If learners know a headword, they will highly likely master its family members much easier (Coxhead, 2000). Relying only on the corpus-based approach, some drawbacks such as the inability to detach the collocate of words from the word lists exist. Thus, the validation process by experts was also included in this study. In this study, the Zoology Academic Word List was validated by seven zoology experts to ensure the appropriateness and practicality of the Zoology Academic Word List. All experts are experienced lecturers from the Faculty of Science who volunteered

to participate in the study. They hold doctorate degrees in science and have been teaching science subjects for at least five years. A detailed written summary of the scope and objectives of this study were sent to all the panel experts. They also received the questions and rating scale. Each of the experts was asked to make an independent judgement based on the question whether the word was a zoology-related or closely related to zoologist, and highly suggested for introduction to zoology students. Opinions and recommendations are also included in the validation form. The results from the experts were calculated using the Item Objective Congruence (IOC) method, resulting in a word being removed if its mean score was lower than 0.67. Word families were later analysed and categorized (*see* Appendix).

4. Results

Information on the common vocabulary and their frequencies as used in the articles in the Zoology Research Article Corpus (ZRAC) is shown in Table 2. The Zoology Academic Word List (ZAWL) is presented with their frequency of occurrence in Table 3.

Table 2 Information on Zoology Research Article Corpus (ZRAC)

Corpus Size	1,530,384 running words
Number of Texts	268 articles
Medium	Written materials in PDF format
Subject	Zoology
Text Types	Research articles
Language	Papers written in English (monolingual corpus)
Publication Dates	January 2016 through February 2019, selected with the intent to avoid outdated words in the corpus

There were 504 words in the Zoology Academic Word List (ZWAL) extracted from Zoology Research Article Corpus (ZRAC). The first ZWAL was selected from ZRAC corpus based on the criteria of specialized scope and objectives of this study. Each of the experts was asked to make an independent judgment to decide whether or not each word was specific to any discipline of zoology and also if it should appear on the list using Item Objective Congruence (IOC) method. The words that had scores lower than 0.67 were removed. A total of 218 words (43.25%) were removed after the validation process; therefore, 286 words in the Zoology Academic Word List (ZAWL) remain after the expert-judge approach as shown in Table 3 below.

Table 3 The Zoology Academic Word Lists (ZAWL) (286 words)

Word	Frequency	Words	Frequency	Words	Frequency
abundant	115	competitor	58	fecundity	128
adductor	107	conservation	572	fertilization	78
adhesive	95	convergence	66	forelimb	104
adipose	52	courtship	83	forelimbs	52
aggression	100	cranial	173	fossil	141
aggressive	102	cryptic	66	fossorial	66
alleles	154	cuticle	55	foster	82
allometric	60	deciduous	106	fracture	118
allometry	125	defence	92	fragmentation	61
amphibia	57	defensive	114	frequencies	118
amphibian	126	demographic	94	gene	255
amphibians	176	demography	51	generalist	103
anatomical	120	density	954	genetics	152
anatomy	162	dental	163	genotype	52
androgen	67	desiccation	89	genus	223
anterior	228	dimorphic	67	geographic	193
antipredator	120	dimorphism	329	gill	84
apical	52	dispersal	388	gizzard	123
aposematic	71	distal	93	gland	128
arthropod	55	diurnal	122	glands	268
arthropods	62	divergence	155	gut	130
autotomy	220	divergent	53	habitat	1470
avian	188	dorsal	231	habitats	634
biodiversity	121	drift	164	haplotype	54
biomass	73	ecological	591	haplotypes	65
bipedal	62	ecology	1086	hatchlings	103
bony	78	ecosystem	131	herbivore	50
breed	138	ecosystems	121	herbivores	71
breeding	931	ectotherms	53	heterogeneity	107
brood	243	eggshell	104	heterozygosity	246
burrow	138	ejaculate	64	hibernation	90
cannibalism	97	elevated	90	hindlimb	143
carapace	68	elevation	167	histological	75
carnivore	226	embryonic	82	hormone	58
carnivores	373	embryo	232	hormones	54
cavity	80	enamel	110	humidity	97
cell	193	endangered	125	hybridization	61
cells	198	ethology	85	immune	146
chromosome	56	extant	81	inbreeding	485
clade	60	extinct	106	incubated	120
coexistence	106	extinction	136	infected	94
coloration	152	fauna	77	intraguild	84
invertebrate	61	nasal	187	polar	116
invertebrates	111	neonate	56	polymorphism	127
juvenile	215	neonates	84	predation	1032
juveniles	166	nestling	59	predator	932
landmarks	84	neural	113	predators	927

Word	Frequency	Words	Frequency	Words	Frequency
larvae	313	niche	336	pregnant	50
larval	315	niches	50	prevalence	172
lateral	270	nocturnal	232	prey	2572
lemurs	77	notochord	127	primate	151
lineage	53	nucleus	51	primates	223
lineages	91	null	123	proximal	92
lipid	98	occipital	51	proximate	57
livestock	106	olfactory	173	proximity	87
localities	56	ontogenetic	106	pups	51
locality	50	ontogeny	123	quadrupedal	74
loci	147	optic	56	recapture	99
locus	82	optimal	118	receptor	64
lowland	83	oral	112	reptile	56
mammal	391	organisms	158	reptiles	177
mammalian	205	oriental	97	reptilian	81
mammals	726	palatal	61	residuals	117
mandible	220	parametric	57	ribs	54
mandibles	67	parasite	352	robust	101
mandibular	97	parasites	236	rodent	121
marsupial	82	parasitic	87	rodentia	57
mates	113	parasitism	72	rodents	256
medial	73	parasitized	57	secretion	52
membrane	58	partitioning	127	segregation	115
metabolic	286	paternal	190	sensory	90
metabolism	65	paternity	60	skeletal	79
metabolites	60	pathology	51	skeleton	56
metamorphosis	212	peaks	59	skull	436
microhabitat	119	pelagic	93	snout	159
microsatellite	151	phenology	67	solitary	77
microsatellites	50	phenotype	112	speciation	96
mitochondrial	81	phenotypes	146	species	5932
morphological	435	phenotypic	261	specimen	181
morphology	543	phylogenetic	252	specimens	322
morphometrics	57	phylogeny	130	stimuli	112
mortality	291	physiological	293	subadult	127
muscle	375	physiology	221	subpopulations	65
muscles	246	pigmented	51	subspecies	72
muscular	58	plasticity	338	subterranean	97
musculature	73	plateau	53	sympatric	237
taxa	317	testis	116	trophic	193
taxonomic	89	thermoregulation	158	tubules	53
temperate	112	thermoregulatory	55	ungulates	146
temporal	346	threshold	99	urine	121
tendon	88	tissue	349	ventral	203
terrestrial	346	tissues	95	vertebrae	114
territorial	113	tolerance	154	vertebral	116
territory	186	trait	167	vertebrate	138
testes	144	traits	670		

The validation form also contained open-ended questions concerning some opinions regarding experts own practical usage of this ZAWL. Some of their comments are as follows:

"I would recommend zoology students to study this list in order to enhance their understanding in zoological literature and to improve their academic writing."

"Despite the fact that many words in the list are not specific to zoology as they are related to general biology, cell biology, ecology, I would recommend zoology students to learn these words because interdisciplinary topics are becoming more relevant."

After the expert validation and word removal process, the researchers categorized the word list into word families. The ZAWL is organized as such so that emergent readers can learn more effectively because word families provide predictable patterns within words.

5. Discussion and Implications

The present study developed a specialized academic word list for the zoology discipline. The corpus-based approach and the expert-judged approach were used to identify specialized academic vocabulary to make the list. The Zoology Academic Research Corpus was derived from 268 articles published in international academic journals recommended by two professors of zoology. The ZAWL was then reviewed by a panel of seven zoology experts. The final list contains 36 word families (*see* Appendix).

The findings of this study confirm a critical perspective from other studies (Valipouri & Nassaji, 2013; Wang, 2017; It-Ngam & Phoocharoensil, 2019), on the fact that developing technical word lists should consider more than just a corpus-based approach. The experts were asked to perform the IOC of each word, as well as providing opinion of these words.

For word families generation, 87 words were classified into 36 word families (*see* Appendix), only 3 of which are word families consisting of at least 4 to 5 words. These words include parasite (1 entries), vertebrate (5 entries) and predator (4 entries). The other 33 word families consist of only 2 to 3 words. After classifying words into word families, this leaves 199 words on the list that are lone-words (non-word family groups).

In this study, the authors developed a zoology academic word list. To the best of our knowledge, this is the only academic word list that has been produced in the field of zoology. Furthermore, the corpus employed in this study is one of the largest of its kind with 1,530,384 running words. Moreover, unlike other studies (e.g., Wang et al., 2008; Yang, 2015) that used only research articles to develop academic wordlists, the present study employed not only the

corpus-approach, but also expert-judge approach. The results of the present research will serve as one of the bases for non-native zoology researchers and postgraduate students to further develop a new understanding of this type of vocabulary and assist them in better use of English for Academic Purposes.

These current research findings offer implications for the zoology discourse community (i.e., zoologists, zoology researchers, zoology students and practically anyone who needs to read, write and research within this discourse community). This is, evidently, because reading, writing, and researching within a given academic community, with its own communicative and social purposes, require its members to have an adequate command of the academic vocabulary that enables effective communication within the community. Teachers and course designers should reference word lists to decide which words in a certain register should be taught to students (Nation & Waring, 1997). Particularly, the Zoology Academic Word List aims to be a ready-to-use word list for instructors and course designers of English for Academic Purposes (EAP) and English for Specific Purposes (ESP) in zoology. Overall, this endeavour is another application of using corpus linguistics and the empirical evidence that will enhance students' learning.

The Zoology Academic Word List (ZAWL) was generated to facilitate teachers, instructors and course designers of English for Specific Purposes (ESP) and English for Academic Purposes (EAP) in terms of selecting appropriate vocabulary to introduce to students. Consequently, an examination of the pedagogical implications of the 286 essential content words of the Zoology Academic Word List (ZAWL) is the next phase that should be included in future studies to validate the benefit of using the ZAWL. Using this word list in an actual classroom will be useful to test its practicality. This provides applicable information about the lexical needs of zoology students.

It is important to acknowledge the limitations of this study. First, this study was conducted on a small scale, so further research should be conducted with a larger number of articles from other journals in the field of zoology to provide a broader perspective into the vocabulary that is used in zoology research articles. This compilation would contribute to enhancing both the diversity of the vocabulary in the corpus and the size of the corpus. Furthermore, a multitude of research papers from varied subject categories of zoology on the ScienceDirect website should be included so as to expand the scale of the Zoology Research Academic Corpus (ZRAC), thereby allowing for a thorough understanding of the vocabulary utilized in zoology research articles. Additionally, further study should consider the process of analysing the coverage of the developed corpus against another corpus of similar discipline, and other corpora of different disciplines. This can quantitatively prove the suitability of the corpus to make a field-specific wordlist. The present study focused on individual words and did not investigate how these lexical items

might collocate with one another. Future studies may inspect the patterns on which these academic words group. Also, the present corpus consisted solely of academic articles. Future studies can incorporate other sources such as textbooks or spoken corpora to determine whether or not our developed wordlist responds to genre changes in the same discipline. Moreover, a larger corpus of more zoology research articles and journals would be significant. Additionally, other kinds of biological science such as botany, evolution, and genetics may be included.

References

Anthony, L. (2013). *AntConc* (Version 3.4. 3) [Computer Software]. Waseda University.

Boonyos, K. (2014). *Establishment of a microbiology academic word list* [Master's thesis, Thammasat University]. TU Digital Collections. https://digital.library.tu.ac.th/tu_dc/frontend/Info/item/dc:94740

Chen, K. Y. (2011). The impact of EFL students' vocabulary breadth of knowledge on literal reading comprehension. *Asian EFL Journal, 51*, 30-40.

Chung, T. M., & Nation, P. (2003). Technical vocabulary in specialised texts. *Reading in a foreign language, 15*(2), 103-116.

Corson, D. (1997). The learning and use of academic English words. *Language Learning, 47*(4), 671-718. https://doi.org/10.1111/0023-8333.00025

Coxhead, A. (2000). A new academic word list. *TESOL Quarterly, 34*(2), 213-238. https://doi.org/10.2307/3587951

Esfandiari, R., & Moein, G. (2015). A corpus-driven food science and technology academic word list. *Issues in Language Teaching, 4*(2), 157-131. https://dx.doi.org/10.22054/ilt.2015.7229

Hsu, W. (2013). Bridging the vocabulary gap for EFL medical undergraduates: The establishment of a medical word list. *Language Teaching Research, 17*(4), 454-484. https://doi.org/10.1177%2F1362168813494121

It-Ngam, T., & Phoocharoensil, S. (2019). The development of science academic word list. *Indonesian Journal of Applied Linguistics, 8*(3), 657-667. https://doi.org/10.17509/ijal.v8i3.15269

Kumar, G. S., Kishore, V., & Radha, D. (2013). The harmony between vocabulary building competency and comprehension skills: Experimental technology-enhanced methods for strengthening word power. *IUP Journal of Soft Skills, 7*(4), 34-39.

Phyllis, K. (1996). *Assessment of academic literacy skills: Preparing minority and LEP (Limited English Proficient) students for postsecondary Education*. CA: California State Univ., Fresno. Dept. of Educational Research. https://eric.ed.gov/?id=ED415498

Li, X., & Li, L. (2015). Characteristics of English for Science and Technology. In X. Du, C. Huang, & Y. Zhong (Eds.), *Proceedings of the 2015 International Conference on Humanities and Social Science Research* (pp. 161-165). Atlantis Press. https://dx.doi.org/10.2991/ichssr-15.2015.31

Liu, J., & Han, L. (2015). A corpus-based environmental academic word list building and its validity test. *English for Specific Purposes, 39*, 1-11. https://doi.org/10.1016/j.esp.2015.03.001

Laufer, B., & Ravenhorst-Kalovski, G. C. (2010). Lexical threshold revisited: Lexical text coverage, learners' vocabulary size and reading comprehension. *Reading in a foreign language*, *22*(1), 15-30.

Martínez, I. A., Beck, S. C., & Panza, C. B. (2009). Academic vocabulary in agriculture research articles: A corpus-based study. *English for Specific Purposes, 28*(3), 183-198. https://doi.org/10.1016/j.esp.2009.04.003

Moghadam, S. H., Zainal, Z., & Ghaderpour, M. (2012). A review on the important role of vocabulary knowledge in reading comprehension performance. *Procedia - Social and Behavioral Sciences, 66*, 555-563. https://doi.org/10.1016/j.sbspro.2012.11.300

Nation, I. (2001). *Learning vocabulary in another language*. Cambridge University Press.

Nation, I. (2006). How large a vocabulary is needed for reading and listening? *Canadian Modern Language Review, 63*(1), 59-82. https://doi.org/10.3138/cmlr.63.1.59

Nation, I. S. P. (2016). *Making and using word lists for language learning and testing*. John Benjamins Publishing Company.

Nation, P., & Waring, R. (1997). Vocabulary size, text coverage and word lists. *Vocabulary: Description, acquisition and pedagogy*, *14*, 6-19.

Ohashi, Y., & Katagiri, N. (2020). The ratios of CEFR-J vocabulary usage compared with GSL and AWL in elementary EFL classrooms and suggestions of vocabulary items to be taught. *Asia Pacific Journal of Corpus Research, 1*(1), 61-94. https://doi.org/10.22925/apjcr.2020.1.1.61

Qian, D. D. (2002). Investigating the relationship between vocabulary knowledge and academic reading performance: An assessment perspective. *Language learning*, *52*(3), 513-536.

Sheng, L., & McGregor, K. K. (2010). Lexical–semantic organization in children with specific language impairment. *Journal of Speech, Language, and Hearing Research, 53*(1), 146-159. https://doi.org/10.1044/1092-4388(2009/08-0160)

Valipouri, L., & Nassaji, H. (2013). A corpus-based study of academic vocabulary in chemistry research articles. *Journal of English for Academic Purposes, 12*(4), 248-263. https://doi.org/10.1016/j.jeap.2013.07.001

Vongpumivitch, V., Huang, J.-Y., & Chang, Y.-C. (2009). Frequency analysis of the words in the Academic Word List (AWL) and non-AWL content words in applied linguistics research papers. *English for Specific Purposes, 28*(1), 33-41. https://doi.org/10.1016/j.esp.2008.08.003

Wang, J., Liang, S.-I., & Ge, G.-c. (2008). Establishment of a medical academic word list. *English for Specific Purposes, 27*(4), 442-458. https://doi.org/10.1016/j.esp.2008.05.003

Wang, P. (2017). A Corpus-based Study of English Vocabulary in Art Research Articles. *Journal of Arts and Humanities, 6*(8), 47-53. https://doi:10.18533/journal.v6i8.1255

Ward, J. (2009). A basic engineering English word list for less proficient foundation engineering undergraduates. *English for Specific Purposes, 28*(3), 170-182. https://doi.org/10.1016/j.esp.2009.04.001

West, M. (1953). *A general service list of English words: With semantic frequencies and a supplementary word-list for the writing of popular science and technology*. Longman; Green.

Yang, M.-N. (2015). A nursing academic word list. *English for Specific Purposes, 37*, 27-38. https://doi.org/10.1016/j.esp.2014.05.003

Zhang, S., & Zhang, X. (2020). The relationship between vocabulary knowledge and L2 reading/listening comprehension: A meta-analysis. *Language Teaching Research*, 1-30. https://doi.org/10.1177/1362168820913998

Appendix

Word Families in Zoology Academic Word List

Word Families		
Parasites 236 Parasite 352 Parasitic 87 Parasitism 72 Parasitized 57	Predation 1032 Predator 932 Predators 927 Antipredator 120	Vertebrates 229 Vertebrate 138 Vertebrae 114 Vertebral 116 Invertebrates 111
Habitat 1470 Habitats 634 Microhabitat 119	Reptiles 177 Reptile56 Reptilian 87	Mandibular97 Mandibles 67 Mandible 220
Mating 581 Mates113	Embryos 232 Embryonic 82	Amphibians 176 Amphibian 57
Breeding 931 Inbreeding 485 Breed 138	Speciation 96 Species 5932 Subspecies 72	Juveniles 166 Juvenile 215
Morphology 543 Morphological 435	Ecology 1086 Ecological 591	Tissue 349 Tissues 95
Proximity 87 Proximate 57 Proximal 92	Locus 82 Loci 147	Metabolic 286 Metabolism 65 Metabolites 60
Physiological 293 Physiology221	Forelimbs 52 Forelimb 104	Elevated 90 Elevation 167
Larval 315 Larvae 313	Herbivore 50 Herbivores 72	Musculature 73 Muscular 58
Arthropods Arthropod 55	Extinct 106 Extinction 136	Locality 50 Localities 56
Paternity 60 Paternal 190	Ecosystems 121 Ecosystem 131	Defensive 114 Defense 92
Asymmetry 138 Symmetrical 51	Forage 174 Foraging 734	Anatomy 162 Anatomical 120
Feed 150 Feeding 982	Testes 144 Testis 116	Territorial 113 Territory 186

*the numbers appeared in the table represent the frequencies.