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The Touch of Nature Has Made the Whole World Kin

INTERSPECIES KIN SELECTION IN THE CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA

LAURA E. JENKINS
Abstract

The unequal distribution of legal protections on endangered species has been attributed to the “charisma” and “cuteness” of protected species. However, the theory of kin selection, which predicts the genetic relationship between organisms is proportional to the amount of cooperation between them, offers an evolutionary explanation for this phenomenon.

In this thesis, it was hypothesized if the unequal distribution of legal protections on endangered species is a result of kin selection, then the genetic similarity between a species and Homo sapiens is proportional to the legal protections on that species. This hypothesis was tested by analyzing the taxonomic classifications of species protected in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The results of this analysis support the hypothesis, for organisms with greater genetic similarity to Homo sapiens (i.e. Animalia, Chordata, Mammalia, Primates, and Hominidae species) were afforded more legal protections in CITES than organisms with less genetic similarity to Homo sapiens.

These results indicate CITES is not an ecocentric law that recognizes the intrinsic worth of non-Homo sapiens, but an anthropocentric law that recognizes the genetic worth non-Homo sapiens have in increasing the indirect fitness of Homo sapiens. Also, these results suggest kin selection can operate between species as opposed to just within species, which indicates the existence of interspecies kin selection. Finally, the existence of interspecies kin selection suggests kin selection could play a role in interspecies cooperation.
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Advice to Future Honors Students

The ability to give advice implies the advisor has something the advisee does not, so perhaps you assume I have years of experience under my belt. In truth, I do not. You likely have more experience than I do, so I will not try to impart impractical advice from the lofty pedestal of “graduating senior”. Instead, I will impart practical advice (minus the pedestal) of why you need to complete an Honors Thesis and how to survive the “dark days” of your Honors Thesis.

Thinking about graduate school? Given that you’re an “Honors Student”, the thought of continuing your education has likely crossed your mind, and there is no better litmus test for graduate school than an Honors Thesis. Therefore, if you want to go to graduate school, you need to complete an Honors Thesis. If you want to devote years of your life to research, you need some experience conducting independent research to ascertain whether research is something you excel at and most importantly, whether research is something you enjoy. I have found research to be an incredibly enjoyable experience, for unlike the rest of the undergraduate experience, you are completely free to develop your own original ideas—no matter how weird they are. However, research is not for the faint of heart, so perhaps the best reason to complete an Honors Thesis is that an Honors Thesis the best litmus test for graduate school because of the “dark days”.

Something may go wrong. Conversely, nothing may go wrong, but you may feel overwhelmed by the data. At times, when analyzing 36,617 pieces of data, I felt “buried” in my data—too entangled in the minutiae to see the big picture. At times I doubted my methods and doubted my conclusions. When you are in these “dark days” try to remember why you first started conducting your research and remember your reaction when you first received the results that strongly supported your hypothesis. Remembering what made you love the research in the first place will help you through the “dark days”.

However, these “dark days” are not all bad, for the “dark days” can help you build a stronger, more cogent paper. Since I doubted my methods and conclusions, I wrote my methods and discussion
with the goal of convincing myself that my methods and conclusions were valid. In the end, this resulted in more cogent argument that thoroughly addressed any apparent obstacles to the validity of my hypothesis. My advice is to not let the “dark days” derail your research, but to allow the “dark days” to let you to become your biggest critic to help ensure the strength of your argument.

Also, experiencing the “dark days” on a small scale in an Honors Thesis will help you determine whether you have the fortitude to overcome the “dark days”, and thus will help prepare you for the “dark days” in graduate school that will likely be on a larger scale. I have heard repeatedly from professors that completing a research paper like an Honors Thesis is very important for success in graduate school. For example, one professor was very happy to hear I had completed an Honors Thesis, for he knew of students who had not had research experience in their undergraduate career and who had failed to complete their dissertations because the experience was too overwhelming and too unfamiliar. By completing an Honors Thesis you are preparing yourself to be successful in graduate school and you are making yourself a more competitive candidate who has a better chance of getting into your dream school and getting the coveted full funding.

In short, you need to complete an Honors Thesis, and yes, it is a good deal of work, so be prepared to spend countless nights writing your Honors Thesis. However, you are an “Honors Student” and if you were incapable of completing an Honors Thesis, you would not be an “Honors Student”, so do not let the work scare you. Also, you will get through the “dark days”—just remember what made you love your topic in the first place and do not be afraid to ask for help. Finally, enjoy your journey and may you come out with original ideas.
Acknowledgements

The acknowledgements section of an Honors Thesis should probably be the simplest part to write, for it is free of hypotheses, mountains of data, and oh so many chi squares. However, it can be the most difficult part to write, for really thanking someone in a paragraph is difficult task. With that said, I would like to thank the director of the Honors Program and my advisor, Dr. William “Bill” Shields. I would like to thank Bill for opening my eyes to the explanatory power of evolution and for helping me discover my academic calling. I’ve never had a single class radically shift my future plans, but Animal Behavior was that kind of a class, due in part to Bill’s teaching style. Additionally, I would like to thank him for providing the environment where I felt completely free (and even encouraged) to pursue unusual (and even weird) ideas that challenged the status quo. I would also like to thank Dr. Elizabeth Vidon and Dr. Robert “Bob” Malmsheimer. I would to thank Dr. Vidon for introducing me to environmental ethics and letting me take her courses despite being a lowly freshmen. I would like to thank Bob Malmsheimer for making the driest legal cases seem so interesting and for bringing the unequal distribution of legal protections on endangered species to my attention.
Introduction

Kindchenschema

Wildlife legal regimes are rife with perplexing inequalities, for some endangered species are protected with highly restrictive legal protections, while others are legally unprotected (Hewitt, 2012). This unequal distribution of legal protections on endangered species has been attributed to the superficial values of “charisma” and “cuteness” (Yaussy, 2012). The role of “cuteness” in species conservation has been explained as a byproduct of Kindchenschema: morphological stimuli that trigger the adaptive behavior of caring for human infants (Lorenz, 1943). Kindchenschema includes features such as a large head, big eyes, and round cheeks, and the degree of Kindchenschema has been shown to influence the amount of parental affection towards an infant (Langlois, Ritter, Casey, & Sawin, 1995) and even our perception of “cuteness” in non-Homo sapiens (Little, 2012). As a result, it was hypothesized that just as the “big eyes, round heads, and short snouts” (Yaussy, 2012) of human infants serve as the proximate cause for a caretaking response, the “big eyes, round heads, and short snouts” of “cute” endangered species likewise serve as a proximate cause for a caretaking response (Golle, Lisibach, Mast, & Lobmaier, 2013).

However, Kindchenschema only explains a proximate cause of endangered species conservation, and neglects the ultimate function—the evolutionary explanation—of endangered species conservation by neglecting the genetic basis of these shared “cute” characteristics. “Cute” species are described as “cute” because they have similar phenotypes to Homo sapiens, and similar phenotypes generally indicate similar genotypes (Futuyma, 2013). If similar genotypes play a role in species conservation, then species conservation is more than a byproduct of protecting offspring with certain phenotypes, but a result of the
fitness benefit conferred by aiding organisms with similar genotypes (Alcock, 2012). The importance of similar genotypes in species conservation indicates that a possible evolutionary explanation for the unequal distribution of legal protections on endangered species is the theory of kin selection.

**Kin Selection**

**Inclusive Fitness Theory**

The theory of kin selection fits into the larger context of inclusive fitness theory, which states natural selection favors organisms with the greatest inclusive fitness: the combination of an organism’s direct fitness and indirect fitness (Alcock, 2012). Fitness describes an organism’s genetic contribution to future generations, and direct fitness describes an organism’s genetic contribution through its offspring and indirect fitness describes an organism’s genetic contribution through its relatives. Kin selection is the mechanism of indirect fitness and describes the evolutionary value—the ultimate function—of behavior. Finally, kin selection predicts the genetic relationship between organisms is proportional to the amount of cooperation between them.

Mathematically, kin selection can be expressed by $rB > C$ (Hamilton’s rule), where when organism one aids organism two $r$ represents the shared genetic material between the two organisms, $B$ represents the reproductive benefit organism two receives from the aid, and $C$ represents the reproductive cost that organism one incurs from the aid (Birch & Okasha, 2015). For example, when organism one helps organism two reproduce, organism one uses resources that could have aided its direct reproduction and thus incurs a direct fitness cost. However, if organism one is related to organism two, organism one incurs an indirect fitness benefit when organism two receives a direct fitness benefit. Organism two shares organism one’s genetic material (with $r$ representing how much genetic material is shared between them), therefore when organism two’s genetic contribution to future generations increases, organism one’s genetic

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1 The reproductive benefit and cost described by Hamilton’s rule are expressed as the increase or decrease in an organism’s genetic contribution to future generations (Alcock, 2012).
contribution to future generations also increases. Put simply, kin selection states it is adaptive for an organism to help its relatives reproduce because relatives share genetic material, and thus helping a relative reproduce increases an organism’s genetic contribution to future generations.

Without the concepts of inclusive fitness and kin selection, helping another organism reproduce at the expense of one’s own reproduction may seem like an altruistic\(^2\) behavior, however kin selection reveals the selfishness behind such seemingly altruistic behaviors (Alcock, 2012). Helping a relative (especially a close relative) reproduce is in an organism’s best interest when the direct fitness cost of the behavior is less than the indirect fitness benefit of the behavior. Thus, even the apparently altruistic sterile worker bees are not “altruists” functioning for the “good of the species”, but self-interested organisms\(^3\) who help extremely close relatives reproduce for the good of their own individual genes (Alcock, 2012, p. 25). The workers bees’ reproductive “sacrifice” is no real sacrifice under inclusive fitness theory, for their “sacrifice” is an adaptive behavior that increases their fitness. Kin selection reveals the selfishness behind acts of “altruism” and is rife with explanatory power, an explanatory power that has been limited to intraspecies interactions.

**Interspecies Kin Selection**

While limiting the explanatory power of kin selection to intraspecies interactions is understandable\(^4\), it is not entirely warranted. Many assert “the principle of kin selection cannot operate

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\(^2\) Altruism will be defined as an action that increases the fitness of the receiver and decreases the fitness of the giver.

\(^3\) The term “self-interested organisms” does not describe the motivations of the organism performing the behavior. Likewise, altruism is not defined by the “selfless” motivations of the “altruist”, but defined by the “selfless” outcomes of the altruist’s behavior. Thus, an adaptive behavior cannot be altruistic, for the outcomes of all adaptive behaviors are “selfish”.

\(^4\) Limiting kin selection’s explanatory power to intraspecies interactions is understandable because of the issues of observability and heritability. Kin selection is most readily observable between very close relatives, where we expect to see large direct fitness costs incurred (such as in the case of sterile worker bees), for the sake of large indirect fitness benefits (Alcock, 2012, p. 25). Thus, when the proportionality of kin selection is more subtle, we have more difficulty finding evidence of kin selection, but absence of evidence for interspecies kin selection is not
across species, ‘natural selection cannot possibly produce any modification in a species exclusively for the good of another species’ (The Origin of Species, chapter 6)” (Futuyma, 2013, p. 305). If a species “produce[d] any modification...exclusively for the good of another species” and neglected its own reproduction in favor of another species’ reproduction, it would inevitably meet with extinction. Such a species would be an evolutionary dead end, and as Darwin correctly asserted, would be an impossibility under natural selection. However, Darwin’s correct assertion bears no connection to Futuyma’s narrow construction of kin selection, despite being invoked as evidence for this construction, and Futuyma’s statement communicates a distorted interpretation of kin selection.

Kin selection is simply a form of individual selection, for it still has the same essential nexus to an individual’s genes as traditional individual selection (Shields, 2015). Kin selection is as relentlessly self-interested as individual selection, and kin selection “cannot possibly produce any modification in a species exclusively for the good of another” individual—regardless of the relatedness between the individuals (Darwin, 1859). Kin selection is about what is best for the individual, not the individual’s kin, and any benefit the individual’s kin receives is simply a byproduct of what is best for the individual (Alcock, 2012). Thus, interspecies kin selection would not result “in a species [operating] exclusively for the good of another species” (Darwin, 1859), but would result in a species aiding related species for its own benefit. Interspecies kin selection would be about what is best for the individuals in species A and any benefit species B received from species A would simply be a byproduct of what is best for the individuals in species A (Coyne, 2009, pp. 120-121).

The labeling of “species A” and “species B” may seem like a choice of convenience, however these evidence of interspecies kin selection’s absence. Also, there is the issue of heritability, for if organism one and organism two are in different species, then when organism one helps organism two reproduce, the behavior cannot increase the frequency of organism one’s alleles in organism one’s species (barring any reciprocal altruism). However, by aiding organism two reproduce, organism one increases the frequency of alleles that it shares with organism two in organism two’s species, thus organism one’s genetic contribution to future generations (fitness) still increases.
labels are significant for A and B are adjacent alphabetically. Thus, interspecies kin selection might be observable between species A and species B, and even between species A and species C, however that interspecies kin selection would likely not be observable in species A and species Z. What this puerile example is meant to highlight is the essence of kin selection—proportionality. Hamilton’s rule indicates there is a proportionality between the amount of aid and cooperation between individuals and their genetic similarity (Alcock, 2012). For example, the proportionality of kin selection has been humorously illustrated by evolutionary biologist Haldane, who stated “Would I lay down my life to save my brother? No, but I would to save two brothers or eight cousins.” (John B. S. Haldane Quotes) Haldane would not sacrifice his life for his brother because the sacrifice would not be proportional to the genetic similarity between Haldane and his brother, for his brother genetically only represents half of Haldane. Conversely, Haldane would “sacrifice” his life for his two brothers or eight cousins because the sacrifice would be proportional to the genetic similarity between the two groups, for either group would genetically represent a complete Haldane.

Similar to Haldane’s example, when a mother sacrifices her life for her child, we observe the proportionality of kin selection, for the high degree of cooperation between a mother and her child is proportional to the high degree of genetic relatedness between them (Alcock, 2012). If the degree of genetic relatedness is lower, then we would then expect the degree of cooperation to be lower as well. For example, we would observe the proportionality of kin selection when first cousins aid each other with monetary gifts. The genetic similarity between first cousins is generally only 12.5% (one-fourth of the genetic similarity between a mother and her child) (Alcock, 2012), and thus we would expect the aid between first cousins to be significantly less than the aid between a mother and child.

Dealing with even less related individuals (such as fourth or fifth cousins) we would expect any aid and cooperation between them to be significantly less than the aid between first cousins, siblings, and parents and children. Kin selection can even be extended beyond extended families, for even an apparent
“altruist” who donates money to homeless shelters or who works in soup kitchens is exhibiting the proportionality of kin selection. The “altruist” is still aiding related individuals (members of her own species), and the aid is roughly proportional to the genetic similarity between the “altruist” and other Homo sapiens. For example, the “altruist” probably donates less money to charity than she gives to her children, and probably spends less time cooking soup at a shelter than she does for her family.

The previous examples have described the proportionality of kin selection within the one species, however the proportionality of kin selection can extend beyond intraspecies interactions. For example, if we return to our “altruist” we might find that she protests animal testing, especially on chimpanzees and other great apes, and since great apes and Homo sapiens belong to the family Hominidae, this behavior can be explained through kin selection. Great apes are closely related to Homo sapiens, and thus we would expect the amount of aid Homo sapiens provide to great apes to be proportional to the genetic similarity between Homo sapiens and great apes. For example, Homo sapiens might donate money to great ape charities, but we would expect that aid to be less than the aid Homo sapiens provide to other Homo sapiens. We might likewise observe the proportionality of kin selection when Homo sapiens aid other primates, other mammals, other chordates, and even other animals, and we would expect as the genetic similarity between an organism and Homo sapiens decreased that the amount of aid would likewise decrease.

Kin selection is a simple statement of proportionality that need not be confined to intraspecies interactions, for all life is kin. The genetic code is universal and phylogenies elucidate genetic relationships between different species, such that we understand which species are more closely related and which are more distantly related (Futuyma, 2013). Kinship extends beyond the confines of a single species, thus kin selection can extend beyond the confines of a single species. If all life is kin, then interspecies kin selection is theoretically possible.
General Hypothesis and Predictions

Returning to endangered species conservation, if the unequal distribution of legal protections on endangered species is a result of kin selection, then the genetic similarity between a species and *Homo sapiens* is proportional to the legal protections on that species. Based on this general prediction, it is predicted the legal protections a species is given is associated with the species' taxonomic classification. It is also predicted within the most restrictive level of legal protections that the numbers of species within the taxonomic groups Animalia, Chordata, Mammalia, Primates, and Hominidae will be greater than the numbers of species within less related taxonomic groups within the same taxonomic level. For example, it is predicted, the most restrictive level of legal protections will protect more Animalia species than Plantae species. It is also predicted, the most restrictive level of legal protections will protect more Chordata species than species in other phyla in Animalia; will protect more Mammalia species than species in other classes in Chordata; and will protect more Primates than species in other orders in Mammalia.

It is also predicted the most restrictive level of legal protections will protect more Animalia species than the number of Animalia species expected if the number of Animalia species within the most restrictive level was proportional to the total number Animalia species in the law and the total number of species protected within the most restrictive level. Likewise, it is predicted the most restrictive level of legal protections will protect more Chordata, more Mammalia, and more Primate species than the numbers of Chordata, Mammalia, and Primate species expected if the numbers of these species in the

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5 These predictions assume the hypothetical law provides different levels of legal protections to endangered species.
6 CITES lists both species and subspecies and lists multiple subspecies as separate entities. For example, the subspecies *Equus hemionus hemionus* and *Equus hemionus khur* are listed separately in Appendix I of CITES. Therefore, when the term “species” is used in this thesis, both species and subspecies are being referred to, and the number of species in a taxonomic group is the sum of species and subspecies within that taxonomic group.
7 It was assumed throughout this thesis *Homo sapiens* are more genetically similar to species in the same taxonomic classifications as *Homo sapiens*. Therefore, it was assumed *Homo sapiens* are more genetically similar to species in the family Hominidae, in the order Primates, in the class Mammalia, in the phylum Chordata, and in the kingdom Animalia.
most restrictive level were proportional to the total numbers of these species in the law and the total number of species protected within the most restrictive level. Finally, it is predicted all Hominidae species (excluding *Homo sapiens*) will be protected in the most restrictive level of legal protections. To test this hypothesis and these predictions the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was analyzed to ascertain whether the genetic similarity between a species and *Homo sapiens* was proportional to the legal protections on that species.

**CITES**

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was created in 1973 to conserve endangered and threatened species by regulating trade in these species (Favre, 1989). CITES is considered one of the few “truly global” treaties (Heijnsbergen, 1997, pp. 27-28), for currently 180 countries are party to the treaty (Member Countries, 2013). These parties are required to implement CITES at the domestic level by appointing a management authority (who issues trade permits) and a scientific authority (who advises the management authority) (Favre, 1989). Parties to the treaty are also encouraged to pass domestic legislation to enforce CITES, however domestic enforcement legislation is often inadequate.

CITES functions as a de facto wildlife conservation law, for while it explicitly regulates international wildlife trade, its primary concern is the continued survival of endangered and threatened species, and the treaty has indeed helped conserve many species (Favre, 1989). CITES explicitly regulates trade and implicitly protects species by listing species in either Appendix I, Appendix II, or Appendix III (Heijnsbergen, 1997). Appendix I lists species that are endangered and is a ban on primarily commercial trade in these species (Favre, 1989). Appendix II lists species that are threatened and restricts but still allows international trade in these threatened species. Appendix III is unlike Appendix I or II, for its trade...
restrictions vary depending on where the species is located. In short, CITES uses a tiered structure of legal protections were species listed on Appendix I are protected with the most restrictive legal protections and those listed in Appendix III are protected with the least restrictive legal protections. The three appendices are the heart of CITES, and the tiered structure of the treaty can only be fully understood by dissecting the subtle differences between these three appendices.

Appendix I

Listing Criteria

Appendix I of CITES protects species “deserving of the highest degree of protection”—endangered species (Favre, 1989, p. 57). For a species to be listed in Appendix I it must be in serious danger of extinction, which is defined as meeting at least one of the following three criteria: “the size of the wild population is small, the area of distribution is restricted, or there is a...marked decline in the population size in the wild” (50 CFR §23.89). Parties to the treaty are instructed to consider factors such as species and habitat fragmentation; habitat quality and quantity; species vulnerability due to its behavior (e.g. migration), life history, ecosystem function, or population structure; decreases in reproductive potential; or threats from exploitation, invasive species, and pollution when deciding whether a species meets one of the three biological criteria for Appendix I (Favre, 1989).

The listing criteria for Appendix I are purposely broad so the “imperfect knowledge” and uncertainty which characterizes conservation does not prevent a critically endangered species from being protected (Cox, 2007). However, having such broad criteria means the listing process is influenced by more than just biological data. What is considered a “small” population size or a restricted area of distribution is so dependent on an organism’s life history and behavior, that it is difficult, if not impossible given the “imperfect knowledge” of conservation to develop reliable biological standards for all species (Favre, 1989). Therefore, biological data alone does not dictate when a population is “small” enough and restricted enough to be listed in Appendix I, and thus the door is opened for other factors to influence
which species are listed in Appendix I. That is not to say species listed on Appendix I are not endangered, but to say there are lurking variables in the listing processes such as economic value and genetic value.

**Trade Procedures**

The permit system for Appendix I is designed to eliminate trade that would be “detrimental to the survival of the species”, and thus contains a number of steps designed to combat everything from corruption, misinformation, or simply mere oversight (Favre, 1989, p. 63). For an Appendix I species to be traded internationally, the shipper must obtain an export permit from the exporting country. The management authority of the exporting country (on the advice of the scientific authority) issues an export permit only when all of the following four conditions for export are met. First, it must be shown the exportation of the specimens will not be detrimental to the survival of the species in the wild (this is called a “non-detrimental finding”). The wording of the first condition favors the species, for it places the burden of proof on showing that the exportation will not be detrimental, as opposed to showing that the exportation will be detrimental to the species’ survival. The first condition permits trade only when there is certainty the trade will be not detrimental to the species, and thus if the species’ survival status is unknown then no potentially detrimental trade will occur.

The second condition for exportation is a determination that the specimens were obtained legally in the exporting country (Favre, 1989). The management authority of the exporting country makes the determination that a specimen was obtained illegally using a burden of proof less restrictive than the “beyond a reasonable doubt” standard used in criminal proceedings, such that a determination of illegality can be made on a “preponderance of the evidence”. CITES also allows parties to enact more restrictive domestic wildlife legislation, so in many countries Appendix I species cannot be obtained legally (Heijnsbergen, 1997). The third condition for exportation is that the specimen must be shipped humanely, so specimens who leave the exporting country alive enter the importing country alive (Favre, 1989).

The final condition for exportation is an import permit (Favre, 1989). An import permit is only
required for Appendix I species, and helps ensure trade in Appendix I species occurs “only in exceptional circumstances” (How CITES Works, 2012). The import permit is an extra safeguard designed to ensure the survival of the species, and is only granted when the importing country independently makes a non-detrimental finding by evaluating the three following criteria (Favre, 1989). First, the specimen can only be imported for purposes that are not “primarily commercial purposes” with commercial being defined as an activity designed to “bring economic benefit” (Conf. 5.10 [Rev. CoP15]). Parties are instructed to define commercial “broadly [in order] to provide maximum protection for Appendix I species”, and an importer must show the non-commercial aspects of importation are the primary purposes of the importation (Conf. 5.10 [Rev. CoP15]). Second, the management authority of the importing country must independently make a non-detrimental finding (Favre, 1989). Finally, if a live specimen is being imported, then the scientific authority must determine if the recipient of the specimen can properly care for the specimen. For example, in the United States an applicant must provide a resume describing the technical expertise of the specimen’s caretakers and must provide a description of the facility where the specimen will be housed. The applicant must also provide the morality rates (from the past two years) of members of the same genus or family as the specimen in the facility where the specimen will be housed, and must provide a description of the cause of death of the organisms and measures taken to prevent their deaths. Such requirements are meant to ensure the wellbeing of the specimen in the importing country.

The importing country’s independent non-detrimental finding acts as a check on oversight, misinformation, and corruption in the exporting country (Favre, 1989). While it is possible for the exporting country to incorrectly make a non-detrimental finding based on oversight or obsolete biological data, it is unlikely for both the exporting country and the importing country to incorrectly make a non-detrimental finding. Thus, the requirement for an import permit helps ensure a non-detrimental finding is made correctly using the best biological data available. The requirement of an import permit also acts as a check on corruption. While it is possible for the government of the exporting country to be corrupt
and allow trade of an Appendix I species without a non-detrimental finding, it is unlikely the governments of the exporting country and the importing country will be corrupt enough to allow trade of an Appendix I species without a non-detrimental finding. Thus, the import permit helps ensure trade in Appendix I species only occurs when an accurate non-detrimental finding has been made.

Additionally, import permits are only granted after the importer has shown they cannot obtain the Appendix I species from a captive breeding program; they cannot use a species not listed on Appendix I for the same purposes; and their purpose cannot be achieved by any alternative means (Favre, 1989). In essence, an importer must show removing the Appendix I species, an action presumed to be detrimental to the species’ survival, is a necessity for a non-commercial purpose. Finally, only a relatively small number of import permits are requested for Appendix I species, and therefore import permits can be reviewed on case by case bases by the management authorities of the importing countries. This case by case review acts a final safeguard against detrimental trade, for the extra scrutiny an import permit receives helps ensure trade in Appendix I species only occurs in compliance with the restrictive requirements of CITES.

The framework of CITES provides Appendix I species with highly restrictive legal protections that ensure trade in these endangered species is only allowed “in exceptional circumstances” (How CITES Works, 2012), and has been correctly characterized as almost a total ban on trade (Favre, 1989). Due to the restrictiveness of Appendix I, listing a species in Appendix I has far reaching economic and political implications. The economic implications are clear, for Appendix I is a ban on primarily commercial trade and these economic implications can create political turmoil. Species listed in CITES are often located in developing nations who would benefit from trading these rare species, thus listing a species in Appendix I can cause economic and political turmoil in these nations and can deepen the “Global North” and “Global South” divide (Smith, 2013). Add these political and economic hurdles to imperfect biological data, and it is clear listing a species in Appendix I is influenced by more than just objective biological facts.
Appendix II

Appendix II is very similar to Appendix I, however a few key distinctions make the legal protections provided in Appendix II far weaker than those in Appendix I (Favre, 1989). Appendix II does not concern endangered species, but threatened species that may become endangered if international trade in the species is not regulated. Therefore, for a species to be listed in Appendix II it either must be likely that without international trade regulations the species will be listed in Appendix I, or must be likely that current levels of international trade in the species are unsustainable. For example, a species would be listed in Appendix II if international trade significantly reduced the species’ population size and thus made it vulnerable to other threats.

Appendix II, unlike Appendix I, is primarily concerned with sustainable economic utilization of threatened species, and therefore seeks to maintain primarily commercial trade in threatened species (Favre, 1989). The objective of Appendix II is to prevent species from becoming so endangered that they are listed in Appendix I, for this would stop all primarily commercial trade in the species. As a result, Appendix II is only concerned with a species’ survival status in order to maintain trade in the species, and thus monitors trade to ensure it is at sustainable levels. Appendix II’s allowance of primarily commercial trade reveals it is primarily concerned with the economic utility of threatened species, unlike Appendix I which is primarily concerned their survival.

While the trade procedures in Appendix II are similar to the procedures in Appendix I, there are two differences that transform the nature of the legal protections provided by each appendix (Favre, 1989). Appendix II requires shippers obtain an export permit from the exporting country, which is issued when the management makes a non-detrimental finding, determines the specimens were obtained legally in the exporting country, and determines the specimens will be shipped humanely. The second and third

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9 The Conference of Parties has helped ensure sustainable trade in Appendix II species by establishing export quotas, which set the maximum number of individuals that can be exported without having a detrimental effect on the species’ survival (“The CITES Export Quotas”, 2015).
conditions of the export permit are identical to the second and third conditions of Appendix I. Conversely, the first condition, while identical in wording to the first condition in Appendix I, is implemented in a significantly different way.

In Appendix I, the non-detrimental finding places the burden of proof on showing the exportation will not have detrimental effects, while in Appendix II, the non-detrimental finding places the burden of proof on showing the exportation will have detrimental effects (Favre, 1989). Shifting the burden of proof for the non-detrimental finding in Appendix II results in a stark contrast, for while the burden of proof in Appendix I results in export permits only being granted in “exceptional circumstances” (How CITES Works, 2012), the burden of proof in Appendix II results in export permits only being denied in “exceptional case[s]” (Favre, 1989). Where the burden of proof is placed changes the very nature of the legal protections these appendices provide, for the burden of proof Appendix I favors the species and the burden of proof in Appendix II favors trade.

A final difference between trade procedures in Appendix I and Appendix II is the import permit, for unlike trade in Appendix I species, trade in Appendix II species does not require an import permit (Favre, 1989). The import permit provides species with substantial and restrictive legal protections and is used to ensure the accuracy of the non-detrimental finding, thus without this extra layer of protection, Appendix II species are made vulnerable to loopholes. Requiring an import permit for trade in Appendix I species is a statement of worth, for it is a statement that Appendix I species are worth the extra time and money issuing an import permit costs. Likewise, when an import permit is not required, it is also a statement of worth, for it is a statement that Appendix II species are not worth the extra time and money issuing an import permit costs. It is a statement that trade of Appendix II species is so valuable it cannot be hindered by the import permit process.

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10 An example of such a loophole was the problem of retrospective issuance of export permits (that was later addressed in Conf. 6.6 [Rev. CoP13]), where trade in Appendix II species was occurring without an export permit (Favre, 1989).
While Appendix II species are protected with international legal protections in CITES, the legal protections protecting Appendix I species are much more restrictive (Favre, 1989). Appendix I’s ban on primarily commercial trade, burden of proof that favors species conservation, and the requirement for an import permit contrasts sharply with Appendix II’s allowance of primarily commercial trade, burden of proof that favors trade, and the lack of a requirement for an import permit. Appendix I can be characterized as an international conservation law, which only allows trade in “exceptional circumstances” (How CITES Works, 2012), while Appendix II can be characterized as an environmentally conscious international trade law, which only prohibits trade in “exceptional case[s]” (Favre, 1989). Appendix I provides species with restrictive legal protections necessary for conservation, while Appendix II provides species with far weaker legal protections necessary for a hybrid framework primarily concerned with trade and partly concerned with conservation.

Appendix III

Appendix III is fundamentally different from Appendix I and Appendix II, for it provides inconsistent legal protections (Favre, 1989). For example, the Gorilla (Gorilla gorilla) is listed in Appendix I and lives in multiple countries throughout Africa (Gorilla, 2015). If these countries are all parties to CITES, then the Gorilla is given the same legal protections in CITES regardless of whether it is in Angola or Cameroon (both parties to the treaty). However, if a species is listed in Appendix III by only party A but resides in party A and party B, then it has legal protections in CITES only in party A but not in party B (Favre, 1989).

In environmental policy there is often a desire for a congruency of scales, a desire to regulate a problem at the level that is occurring (Smith, 2013). For example, when regulating a “common pool resource” such as wildlife (which does not respect the borders of the statist system), the desire is to regulate this international issue at the international scale (Armstrong, Farrell, & Lambert, 2012). Conversely, domestic regulations aimed at an international environmental issue (without the support of
international law) are often thought to be somewhat ineffective (Smith, 2013), for how effective can wildlife conservation laws be when the species is being overexploited just across the border? As a result, Appendix III provides species with the least restrictive legal protections because the legal protections it provides are inconsistent, meaning Appendix III species are still vulnerable to overexploitation (Favre, 1989).

Since Appendix III provides the weakest legal protections of the three appendices, its listing procedure is far more flexible than Appendix I and Appendix II (Favre, 1989). For a species to be listed in Appendix I or II, 120 parties must approve its listing (Member Countries, 2013), while one party may list a species in Appendix III (Favre, 1989). Also, for a species to be listed in Appendix I or II, it has to meet certain (although very broad) biological criteria, while for a species to be listed in Appendix III it does not have to meet any international standards for being threatened or endangered. For a species to be listed in Appendix III there must be domestic legislation in the listing party that regulates the species\textsuperscript{11}, and international trade regulations must be necessary for the domestic legislation to be effective. Appendix III is designed to aid parties domestically regulating a species by providing some international legal protections, so international trade in a species does not thwart a party’s efforts at conserving the species.

The procedure for trading an Appendix III species varies depending on its country of origin (Favre, 1989). If an Appendix III species originates in a listing party, then an export permit is required from the management authority of the listing party. The management authority only has to determine whether the specimens were obtained legally in the listing party and whether the specimens will be shipped humanely before granting an export permit. Unlike Appendix I and Appendix II, Appendix III does not require a non-detrimental finding, so a management authority could grant an export permit even if the exportation threatened the species’ survival.

Conversely, if the species originates in a non-listing party, then the management authority of that

\textsuperscript{11} A party can only list a species in Appendix III if the species lives within the jurisdiction of the listing party.
party issues a certificate of origin, which shows the specimens originated in a non-listing party (Favre, 1989). However, the management authority may have difficulty determining where specimens originated, and this creates a loophole for illegal trade. For example, a specimen living in a listing party may be smuggled into a non-listing party and may “legally” enter international trade under CITES without first being subjected to the domestic regulations of the listing party. Finally, if specimens are imported into a party that recognizes the specimens as protected then an import permit is required. However, if the party does not recognize the specimen as protected then only a certificate of origin or export permit is needed. Thus, Appendix III provides inconsistent legal protections and the wellbeing of an Appendix III species relies solely on the strength of domestic legislation in listing parties and not on CITES.

Summary

In short, Appendix I places the most restrictive legal protections on species and functions as an international wildlife conservation law (Favre, 1989). Conversely, Appendix II places less restrictive and therefore weaker legal protections on species and functions as an environmentally conscious international trade law. Finally, Appendix III places inconsistent and therefore very weak legal protections on species and functions as a semi-international trade law. While all three appendices of CITES seek to protect wildlife, they are so different in their purposes they almost are three separate laws.

Hypothesis and Predictions Applied to CITES

If the unequal distribution of legal protections in CITES is a result of kin selection, then the genetic similarity between a species and *Homo sapiens* is proportional to the restrictiveness of the legal protections CITES places on the species. Thus, it is predicted the appendix a species is listed in is associated with the species’ taxonomic classification. Since Appendix I places the most restrictive legal protections on species (Favre, 1989), it is predicted Appendix I will list more Animalia species than Plantae species. It is also predicted Appendix I will list significantly more Chordata species than species in other phyla in
Animalia; will list significantly more Mammalia species than species in other classes in Chordata; and will list more Primates than species in other orders in Mammalia.

It is also predicted Appendix I will list significantly more Animalia species than the number of Animalia species expected if the number of Animalia species in Appendix I was proportional to the total number Animalia species in CITES and the total number of species listed in Appendix I. Likewise, it is predicted Appendix I will list significantly more Chordata, more Mammalia, and more Primate species than the expected number of Chordata, Mammalia, and Primate species if the numbers of Chordata, Mammalia, and Primate species in Appendix I were proportional to the total numbers of Chordata, Mammalia, and Primate species in CITES and the total number of species listed in Appendix I. Finally, it is predicted the entire family of Hominidae (excluding Homo sapiens) will be listed in Appendix I. Also, given the high percentage of genetic material Hominidae and Primate species share with Homo sapiens, it is predicted all Hominidae and Primate species will be listed in CITES and will not be listed in Appendix III of CITES.
Methods

The hypothesis that the unequal distribution of legal protections on endangered species is a result of kin selection was tested by comparing the number of species in different taxonomic groups within one taxonomical level (e.g. the kingdom, phylum, class, order, or family level) within the three appendices of CITES. Thus, the complete taxonomy of each species and the correct number of species and subspecies within each taxonomic group listed in the three appendices of CITES was needed to assess the validity of the hypothesis.

Why CITES?

CITES was selected for this thesis because it met two basic requirements. First, in order to test the predictions relating to the legal protections on Animalia, Chordata, Mammalia, Primates, and Hominidae species, the law or treaty needed to protect all of these species. Second, the law or treaty needed to contain more than one level of legal protections. CITES met both requirements, for its listed Animalia, Chordata, Mammalia, Primates, and Hominidae species, and contained three different levels of legal protections.

If CITES only contained one level of legal protections, then the validity of the hypothesis could only be assessed by comparing the number of species in one taxonomic group closely related to Homo sapiens to the numbers of species in other taxonomic groups not closely related to Homo sapiens. However, relying solely on the numbers of species in taxonomic groups is a flawed method. Different taxonomic groups have very different number of species within them (Futuyma, 2013), and thus it would be difficult to assess the validity of the hypothesis. For example, a law with only one level of legal protections listed every species in order A, containing 25,000 species, and every species in order B, containing 600 species. Now, if order A was more genetically similar to Homo sapiens than order B, could the validity of the hypothesis be assessed? Is the number of species listed in the law reflective of kin
selection or simply reflective of the number of species with the order? Such a question would be nearly impossible to answer.

Conversely, the current method does not solely rely on the number of species within a taxonomic group, but relies primarily on the legal protections provided to a taxonomic group and then takes into account the number of species within the taxonomic group. The hypothesis addresses the level of legal protections provided to endangered species, however CITES only has three levels of legal protections, and thus many different species are listed within each level. Therefore, it would be impossible to assess the validity of the hypothesis by only analyzing the level of the legal protections a taxonomic group was provided. Thus, to assess the validity of the hypothesis the composition of each appendix of CITES was analyzed by calculating the numbers of species within each taxonomic group. The composition of each appendix was then used to assess the validity of the hypothesis, such that if the most restrictive level of legal protections, Appendix I, was comprised mostly of species with a high degree of genetic similarity to \textit{Homo sapiens}, then the hypothesis would be supported.

Materials

To analyze the taxonomy of each species listed in CITES, the three appendices of CITES were downloaded separately as CSV files from \url{http://checklist.cites.org/}. However, this resource did not provide the correct number of species\textsuperscript{12} within each taxonomic group in CITES\textsuperscript{13} (despite being produced by the United Nations Environmental Program—World Conservation Monitoring Center), thus to analyze the number of species within each taxonomic group listed in CITES, other resources had to be utilized. The

\textsuperscript{12} As discussed earlier, CITES lists both species and subspecies and therefore, the number of species in a taxonomic group refers to the sum of species and subspecies within that taxonomic group.

\textsuperscript{13} Given the inherent difficulty in comparing organisms as different as plants and primates, every effort was taken to compare like with like, which for the purposes of this thesis was chosen to be the number of species and subspecies. The CSV files produced by the UNEP listed not only each protected species, but also listed protected subspecies, genera, families, and orders, meaning the number of species and subspecies within each protected genus, family, and order was not listed in these CSV files. Therefore, the number of species and subspecies in each protected genus, family, and order needed to be ascertained, so accurate numbers of species and subspecies in different taxonomic classifications could be compared.
World Registry of Marine Species (http://www.marinespecies.org/), Mammal Species of the World, addition CITES produced resources at (http://www.cites.org/eng/disc/species.php), and a number of primary research papers (listed in Appendix B) were used to ascertain how many species were in each listed genus, family, and order. Every effort was made to compile accurate numbers of species\textsuperscript{14}, however given debates surrounding certain taxonomic classifications, and given the size of the appendices it is possible the numbers of species in this thesis are not be completely accurate. However, every listed genus, family, and order was researched to ascertain the correct number of species within these taxonomic levels.

Methodology

Each appendix of CITES was downloaded as a separate CSV file and then was organized into different Excel sheets based on taxonomy. The Appendix I CSV file generated five Excel sheets which listed all species in Appendix I, all Animalia species in Appendix I, all Chordata species in Appendix I, all Mammalia species in Appendix I, and all Primates in Appendix I. The same procedure was repeated for Appendix II and Appendix III, however in Appendix III a sheet listing only Primates was not created. Finally, a complete list of all species in the three appendices was created by combining the lists of all species in each appendix.

The analysis of the numbers of species within taxonomic groups in CITES was restricted to taxonomic groups relevant to the validity of the hypothesis. The taxonomic groups most relevant to the hypothesis were Animalia, Chordata, Mammalia, Primates, and Hominidae. However, to ascertain the

\textsuperscript{14}The goal of the thesis was to test the hypothesis that the unequal distribution of legal protections on endangered species is a result of kin selection, not to make CITES taxonomically accurate. As a result, if CITES listed a species under a name that is no longer used by taxonomists and the name change would not affect the results of the thesis, the name was not corrected. For example, the family names of many Cnidaria species listed in Appendix II are no longer used and have been replaced with other family names, however these names were not corrected since the family a Cnidaria species belonged to would not impact the results of this thesis. Also, changing the names might lead to more confusion, especially if not done for every listed species in CITES.
legal protections provided to these groups, the numbers of Animalia, Chordata, Mammalia, Primates, and Hominidae species were compared with the numbers of species within less related taxonomic groups within the same taxonomic level. Therefore, to ascertain the legal protections provided to Animalia species, within each appendix of CITES, the number of Animalia species was compared to the number of Plantae species. Thus, the analysis at the taxonomic level of the kingdom encompassed every species in CITES.

Conversely, the analysis of each subsequent taxonomic level was nested within the taxonomic group most related to Homo sapiens within the previous taxonomic level. Therefore, the analysis at the taxonomic level of the phylum was restricted to Animalia species, and thus to ascertain the legal protections provided to Chordata species, the number of Chordata species was compared to the number of species within other phyla in Animalia. Likewise, the analysis at the taxonomic level of the class was restricted to Chordata species, thus the number of Mammalia species was compared to the number of species in other classes in Chordata. Additionally, the analysis at the taxonomic level of the order was restricted to Mammalia species, thus the number of Primates was compared to the number of species in other orders in Mammalia. Finally, the analysis at the taxonomic level of the family was restricted to Primates, the number of Hominidae species was compared to the number of species in other families in Primates.

In this thesis, the analysis of the number of species in CITES was restricted to comparisons where the genetic similarity between Homo sapiens and taxonomic groups could be judged by taxonomy. For example, the numbers of species within different classes of the phylum Cnidaria were not analyzed because a Cnidaria species’ class does not indicate a Cnidaria species’ genetic similarity to Homo sapiens. Conversely, the numbers of species within different classes of Chordata were analyzed because a Chordata species’ class does indicate a Chordata species’ genetic similarity to Homo sapiens. The goal of this thesis was to assess the validity of the hypothesis, not to catalog the complete taxonomy of every
species listed in CITES, therefore the analysis of CITES was restricted to comparisons relevant to the hypothesis.

To evaluate the validity of the hypothesis, the composition of Appendix I, Appendix II, and Appendix III in CITES was analyzed using a chi square test for independence, homogeneity of proportions, and goodness of fit. The level of significance of all chi square tests performed in this thesis was $\alpha=0.001^{15}$. A chi square test for independence was performed to assess whether the legal protections a species was given (i.e. which the appendix the species was listed in) was associated with the species’ taxonomic classification. A chi square test for homogeneity of proportions was performed to assess whether the number of species in a taxonomic group deviated from the number of species expected in that taxonomic group if the number of species in that taxonomic group was proportional to the total number of species in that taxonomic group in CITES and the total number of species listed in that appendix. A chi square goodness of fit test was performed to assess whether the numbers of species within the taxonomic groups Animalia, Chordata, Mammalia, Primates, and Hominidae were equal to the numbers of species not within these taxonomic groups but within the same taxonomic level within one appendix of CITES. Also, if greater than 20% of the expected values in either the chi square homogeneity of proportions test or the chi square goodness of fit test were less than five (a violation of one of the assumption of chi square tests), categories (taxonomic groups) were combined based on phylogenetic relationships, such that closely related groups were placed in the same category.

Finally, the diversity of each kingdom, phylum, and class in CITES was assessed by calculating the number of orders within these taxonomic groups. Where the values were large enough, a chi square homogeneity of proportions test was performed to assess whether the numbers of orders within each kingdom, phylum, and class in CITES deviated significantly from the expected numbers of orders (if the

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15 Assessing the validity of a hypothesis based on the number of species is difficult, for different taxonomic groups have very different number of species within them, so to correct for these flaws a very low $\alpha$ value for significance was chosen ($\alpha=.001$).
number of orders within these taxonomic groups was proportional to the total number of orders in these taxonomic groups in CITES and the total number of orders listed in that appendix. Likewise, (where the values were large enough) a chi square goodness of fit test was performed to assess whether the numbers of orders within each kingdom, phylum, and class in CITES were equal.

The number of orders were calculated in order to assess whether one or a few orders compromised the majority of species listed in a kingdom, phylum, or class. This assessment was made by comparing the number of species in a taxonomic group to the number of orders within that taxonomic group. For example, within one taxonomic level, if the majority of species belonged to one taxonomic group, and yet the majority of orders belonged to another taxonomic group, this would indicate one or few orders compromised the majority of species listed within that taxonomic level. No predictions were made regarding the hypothesis and the number of orders within each taxonomic group because of the difficulty of assessing whether the diversity of a taxonomic group represented in CITES had any bearing on the legal protections provided to that taxonomic group.

Summary

To assess the validity of the hypothesis that the unequal distribution of legal protections on endangered species is a result of kin selection, the numbers of species in different taxonomic groups within one taxonomical level within Appendix I, Appendix II, and Appendix III of CITES were calculated. The numbers of species in CITES were then analyzed using chi square tests for independence, homogeneity of proportions, and goodness of fit, in order to assess whether the genetic similarity between a species and *Homo sapiens* is proportional to the legal protections on that species.
Results

All Three Appendices of CITES Combined

Over 80% of the species listed in the three appendices of CITES were Plantae species, while less than 20% were Animalia species (Figure 1). The majority of Animalia species were Chordata species and approximately one-third of Animalia species were Cnidaria species (Figure 2). Amongst Chordata species, more Aves species were listed than Mammalia species (Figure 3), and the majority of Mammalia species were Primates (Figure 4).

The appendix a species was listed in and the species’ taxonomic classification—a species’ kingdom \( \chi^2 (1, N=36617)=2926.34, p<0.0001; \) Table 1, an Animalia species’ phylum \( \chi^2 (5, N=6262)=993.59, p<0.0001; \) Table 1, a Chordata species’ class \( \chi^2 (6, N=3966)=2193.42, p<0.0001; \) Table 1, and a Mammalia species’ order \( \chi^2 (17, N=1195)=328.89, p<0.0001; \) Table 1—were associated.

Appendix I

Kingdom

Over two-thirds of the species listed in Appendix I were Animalia species (Figure 5), thus each kingdom was not represented equally in Appendix I \( \chi^2 (1, N=1157)=156.11, p<0.0001; \) Appendix A:Table 2 and Table 3. Additionally, in the chi square homogeneity of proportions test, the actual number of Animalia species in Appendix I exceeded the expected number of Animalia species by almost 600 species, thus the numbers of Animalia and Plantae species in Appendix I were not proportional \( \chi^2 (1, N=1157)=2144.86, p<0.0001; \) Appendix A:Table 4 and Table 5.

Eighty percent of the orders in Appendix I were in the kingdom Animalia (Figure 6), thus each kingdom in Appendix I was not equally diverse \( \chi^2 (1, N=65)=23.40, p<0.0001; \) Appendix A: Table 6 and Table 7. However, the number of orders in Animalia and Plantae in Appendix I did not deviate significantly
from the expected numbers in the chi square homogeneity of proportions test $\chi^2 (1, N=65)=1.73, p>0.001$;
Appendix A: Table 8 and Table 9

Phylum

More than 90% of the Animalia species listed in Appendix I were Chordata species (Figure 7), thus each phylum was not represented equally in Appendix I $\chi^2 (5, N=791)=1207.60, p<0.0001$; Appendix A: Table 10 and Table 11. Additionally, in the chi square homogeneity of proportions test, the actual number of Chordata species in Appendix I exceeded the expected number of Chordata species by over 200 species, thus the number of species in Annelida, Arthropoda, Chordata, Cnidaria, Echinodermata, and Mollusca in Appendix I were not proportional $\chi^2 (2, N=791)=447.14, p<0.0001$; Appendix A: Table 12 and Table 13.

Almost 95% of the Animalia orders in Appendix I were in the phylum Chordata (Figure 8), thus each phylum in Appendix I was not equally diverse $\chi^2 (2, N=52)=86.81, p<0.0001$; Appendix A: Table 14 and Table 15. The expected values were too low to perform a chi square homogeneity of proportions test.

Class

More than half of the Chordata species in Appendix I were Mammalia species (Figure 9), thus each class was not represented equally in Appendix I $\chi^2 (6, N=732)=1340.55, p<0.0001$; Appendix A: Table 16 and Table 17. Additionally, in the chi square homogeneity of proportions test, the actual number of Mammalia species in Appendix I exceeded the expected number of Mammalia species by over 200 species, thus the number of species in Actinopterygii, Amphibia, Aves, Elasmobranchii, Mammalia, Reptilia, and Sarcopterygii in Appendix I were not proportional $\chi^2 (4, N=732)=268.43, p<0.0001$; Appendix A: Table 18 and Table 19.

Over 40% of the orders in Chordata in Appendix I were in the class Aves (Figure 10) and almost 30% of the orders in Chordata in Appendix I were in the class Mammalia, thus each class in Chordata in
Appendix I was not equally diverse $\chi^2 (6, N=50)=48.56, p<0.0001$; Appendix A: Table 20 and Table 21. The expected values were too low to perform a chi square homogeneity of proportions test.

**Order**

Over half of the Mammalia species in Appendix I were Primates (Figure 11), thus each class was not represented equally in Appendix I $\chi^2 (13, N=419)=1446.88, p<0.0001$; Appendix A: Table 22 and Table 23. In the chi square homogeneity of proportions test, the actual number of Primates in Appendix I was two species less than the expected number of Primates, therefore the number of species in the eighteen Mammalia orders in Appendix I did not deviate significantly from expected number of species $\chi^2 (6, N=419)=21.76 p>0.001$; Appendix A: Table 24 and Table 25.

**Family**

The family Hominidae represented less than three percent of Primates in Appendix I (Figure 12), however all Hominidae species (excluding *Homo sapiens*) were listed in Appendix I.

**Appendix II**

**Kingdom**

Almost 85% of the species in Appendix II were Plantae species (Figure 13), thus each kingdom was not represented equally in Appendix II $\chi^2 (1, N=35,286)=17236.70, p<0.0001$; Appendix A: Table 2 Table 1 and Table 3: Chi Square Goodness of Fit Test for the Number of Species in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES. Also, in the chi square homogeneity of proportions test, the actual number of Plantae species in Appendix II exceeded the expected number of Plantae species by over 700 species, thus the numbers of species in Animalia and Plantae in Appendix II were not proportional $\chi^2 (1, N=35,286)=104.32, p<0.0001$; Appendix A: Table 4 and Table 5.

Over two-thirds of the orders in Appendix II were in the kingdom Animalia (Figure 14), thus each kingdom in Appendix II was not equally diverse $\chi^2 (1, N=91)=11.97, p<0.001$; Appendix A: Table 2.
Also, the number of orders in Animalia and Plantae in Appendix II did not deviate significantly from the expected number of orders $\chi^2 (1, N=91)=0.97, p>0.001$; Appendix A: Table 8 and Table 9.

**Phylum**

More than half of the Animalia species in Appendix II were Chordata species and almost 40% of the Animalia species in Appendix II were Cnidaria species (Figure 15). Therefore, each phylum was not represented equally in Appendix II $\chi^2 (4, N=5312)=7959.38, p<0.0001$; Appendix A: Table 26 and Table 11. The numbers of species in Annelida, Arthropoda, Chordata, Cnidaria, Echinodermata, and Mollusca in Appendix II were not proportional $\chi^2 (2, N=5312)=98.72, p<0.0001$; Appendix A: Table 12 and Table 13.

Almost 75% of the orders in Appendix II were in the phylum Chordata (Figure 16), thus each phylum in Appendix II was not equally diverse $\chi^2 (4, N=62)=114.94, p<0.0001$; Appendix A: Table 27 and Table 15. The expected values were too low to perform a chi square homogeneity of proportions test.

**Class**

Almost half of the Chordata species in Appendix II were Aves species and more Aves and Reptilia species were listed in Appendix II than Mammalia species (Figure 17). As a result, each class was not represented equally in Appendix II $\chi^2 (6, N=3109)=3945.75, p<0.0001$; Appendix A: Table 28 and Table 17. The actual number of Mammalia species in Appendix II (in the chi square homogeneity of proportions test) was over 200 species below the expected number of Mammalia species and the actual number of Aves species in Appendix II exceeded the expected number of Aves species by over 150 species. Thus, the numbers of species in Actinopterygii, Amphibia, Aves, Elasmobranchii, Mammalia, Reptilia, and Sarcopterygii in Appendix II were not proportional $\chi^2 (4, N=3109)=78.71, p<0.0001$; Appendix A: Table 18 and Table 19.

Aves contained the most orders in Chordata listed in Appendix II and was followed closely by
Mammalia (Figure 18), thus each class in Chordata listed in Appendix II was not equally diverse \( \chi^2 (6, N=46)=34.16, p<0.0001; \) Appendix A: Table 29 and Table 21. The expected values were too low to perform a chi square homogeneity of proportions test.

**Order**

Over half of the Mammalia species in Appendix II were Primates (Figure 19), and Appendix II lists all Primates that were not listed in Appendix I. As a result, each class was not represented equally in Appendix II \( \chi^2 (13, N=713)=2987.65, p<0.0001; \) Appendix A: Table 30 and Table 23. The numbers of species in the orders of Mammalia in Appendix I did not deviate significantly from expected numbers in the chi square homogeneity of proportions test \( \chi^2 (6, N=713)=35.45 p>0.001; \) Appendix A: Table 24 and Table 25.

**Family**

No Hominidae species were listed in Appendix II, for the six members of the family (excluding *Homo sapiens*) all were listed in Appendix I.

**Appendix III**

**Kingdom**

Over 90% of the species in Appendix III were Animalia species (Figure 20), thus each kingdom was not represented equally in Appendix III \( \chi^2 (1, N=174)=119.17, p<0.0001; \) Appendix A: Table 2 and Table 3. Also, the numbers of Animalia and Plantae species in Appendix III were not proportional \( \chi^2 (1, N=174)=677.16, p<0.0001; \) Appendix A: Table 4 and Table 5.

Over 70% of the orders in Appendix III were in the kingdom Animalia (Figure 21), however each kingdom in Appendix III did not deviate significantly from the expected numbers in the chi square goodness of fit test \( \chi^2 (1, N=31)=5.45, p>0.001; \) Appendix A:Table 6 and Table 7. Also, the number of orders in Animalia and Plantae in Appendix III did not deviate significantly from expected numbers in the chi square homogeneity of proportions test \( \chi^2 (1, N=31)=0.05, p>0.001; \) Appendix A:Table 8 and Table 9.
Phylum

Almost 85% of the Animalia species in Appendix III were Chordata species (Figure 22), therefore each phylum was not represented equally in Appendix III $\chi^2 (3, N=159)=303.21, p<0.0001$; Appendix A: Table 31 and Table 11. The numbers of species in Annelida, Arthropoda, Chordata, Cnidaria, Echinodermata, and Mollusca in Appendix II were not proportional $\chi^2 (2, N=159)=108.45, p<0.0001$; Appendix A: Table 12 and Table 13.

Over 80% of the orders in Appendix III were in the phylum Chordata (Figure 23), thus each phylum in Animalia in Appendix III was not equally diverse $\chi^2 (3, N=22)=38.00, p<0.0001$; Appendix A: Table 32 and Table 15. The expected values were too low to perform a chi square homogeneity of proportions test.

Class

Almost half of the Chordata species in Appendix III were Mammalia species (Figure 24), thus each class was not represented equally in Appendix III $\chi^2 (3, N=134)=55.91 p<0.0001$; Appendix A: Table 33 and Table 17. The numbers of species in Actinopterygii, Amphibia, Aves, Elasmobranchii, Mammalia, Reptilia, and Sarcopterygii in Appendix III were not proportional $\chi^2 (4, N=134)=35.28, p<0.0001$; Appendix A: Table 18 and Table 19.

Aves had the highest number of orders in Chordata in Appendix III and was followed closely by Mammalia (Figure 25). The expected values were too low to perform a chi square goodness of fit test and a chi square homogeneity of proportions test.

Order

Appendix III listed no Primates, for all of these species were listed in Appendix I or Appendix II.
Discussion

The hypothesis that the unequal distribution of legal protections on endangered species is a result of kin selection was supported by the analysis of the taxonomy of the species listed in CITES. Species with a high degree of genetic similarity to Homo sapiens (e.g. Animalia, Chordata, Mammalia, Primates, and Hominidae species) were provided with highly restrictive legal protections in CITES, thus the genetic similarity between a species and Homo sapiens was proportional to the legal protections on that species. Therefore, there is strong evidence that the unequal distribution of legal protections on endangered species is a result of kin selection. Likewise, there is also strong evidence CITES is an anthropocentric treaty and that interspecies kin selection can explain cases of interspecies cooperation.

Species in the Three Appendices of CITES Combined

The inherent difficulty of comparing widely different species is revealed when comparing orders such as Orchidales, which contains over 25,000 species, and Primates, which contains 633 species and subspecies (excluding Homo sapiens). In response to this difficulty, the hypothesis that the unequal distribution of legal protections on endangered species is a result of kin selection measured the qualitative aspect of legal protections, so it would not be skewed by the quantitative aspect of the number of species in each taxonomic classification. Therefore, the number of species in each taxonomic classification in CITES as whole has no bearing on the hypothesis. So, while the total number of Plantae species and Animalia species in CITES may seem to contradict the hypothesis, for the vast majority of species in CITES are Plantae species, these numbers have no bearing on the hypothesis. Likewise, while the total number of Aves species compared to Mammalia species in CITES may seem to contradict the hypothesis; while the total number of Chordata species in CITES may seem to support the hypothesis; and while the total number of Primates species in CITES may seem to support the hypothesis, all of these numbers have no bearing on the hypothesis. The hypothesis predicts the genetic similarity between a species and Homo sapiens.
sapiens is proportional to the legal protections on that species, not proportional to the number of species legally protected, and therefore the number of species listed in CITES as a whole is irrelevant. Conversely, the restrictiveness of the legal protections used to protect species in CITES was relevant to the hypothesis, thus the appendix a species was listed in was used to assess the validity of the hypothesis.

Association between appendix and taxonomic classification

Which appendix of CITES a species was listed in was central to the hypothesis, therefore it was predicted the appendix a species was listed in was associated with the species’ kingdom, phylum, class, and order. These predictions were supported by the results, for the appendix a species was listed in was associated with the species’ kingdom, phylum, class, and order. However, while an association between a species’ taxonomy and the appendix of CITES it was listed in provides a foundation for the hypothesis, association in insolation does not support the hypothesis. For the hypothesis to be supported there must not only be an association between the taxonomic group a species belonged to and the appendix of CITES the species was listed in, but there must also be a pattern of species in taxonomic groups more related to Homo sapiens receiving more legal protections than species in less related taxonomic groups. In the context of CITES, this means Animalia, Chordata, Mammalia, Primates, and Hominidae species should be listed in Appendix I, and should have more species (with the exception of Hominidae) listed in Appendix I than species less related to Homo sapiens.

Appendix I

It was predicted species more related to Homo sapiens would have more species listed in Appendix I than species less related to Homo sapiens within the same taxonomic level. Therefore, it was predicted Appendix I would list significantly more Animalia species than Plantae species, and Appendix I did list significantly more Animalia species than Plantae species. Also, Appendix I listed almost 600 more Animalia species than the expected number of Animalia species in the chi square homogeneity of
proportions test. Thus, while far more Plantae species are listed in all of CITES, far more Animalia species are listed in the appendix with the most restrictive legal protections, legal protections proportional to Animalia’s genetic similarity to *Homo sapiens*.

Likewise, it was predicted Appendix I would list significantly more Chordata species than species in other phyla in Animalia; would list significantly more Mammalia species than species in other classes in Chordata; and would list significantly more Primates than species in other orders in Mammalia. These predictions were supported by the results, for in Appendix I almost all Animalia species were Chordata species; the majority of Chordata species were Mammalia species; and the majority of Mammalia species were Primates.

Appendix I listed more Mammalia species than Aves species, however it also listed more Aves orders than Mammalia orders. This discrepancy between the number of species and orders is a result of most Mammalia species in Appendix I coming from one order—Primates. Primates represent such a large percentage of Mammalia species in Appendix I that the diversity of Mammalia is less than would be expected given number of species within Mammalia. Thus, the measure of diversity reaffirms the importance of Primates in Appendix I and reaffirms that Primates were the most protected order of Mammalia species in CITES. In short, Primates in CITES were provided with highly restrictive legal protections proportional to their genetic similarity to *Homo sapiens*.

Additionally, Appendix I listed significantly more Chordata species and more Mammalia species than the expected number of Chordata species and Mammalia species in the chi square homogeneity of proportions test. Finally, as predicted, the entire family of Hominidae (excluding *Homo sapiens*) was listed in Appendix I. Conversely, the number of Primates in Appendix I was not significantly higher than the expected number of Primates in the chi square homogeneity of proportions test, and the expected number of Primates was two species higher than the actual number of Primates. However, the lack of deviation from expected number of Primates in Appendix I does not refute the hypothesis, and can be
explained by the number of Primates in all of CITES and the deviation from the expected numbers of Primates in Appendix II and Appendix III.

The lack of deviation in Appendix I is a result of the high number of Primates listed in CITES, for no other order in Mammalia in CITES lists as many species as Primates. Therefore, the expected number of Primates in Appendix I was large, thus a lack of deviation from this large number supports the hypothesis. Given the genetic similarity between Homo sapiens and Primates, it was predicted large numbers of Primates would be listed in Appendix I, and this prediction was supported by the results, for the majority of Mammalia species listed in Appendix I were Primates. Thus, the representation of Primates in Appendix I supports the hypothesis and the lack of deviation from the expected number of Primates in Appendix I does not refute the hypothesis.

The lack of deviation from the expected number of Primates in Appendix I can also be explained by the deviations from the expected numbers of Primates in Appendix II and Appendix III. The number of Primates in Appendix II is approximately 35 species higher than the expected number of Primates, and this deviation is caused by Appendix II listing all Primates not listed in Appendix I and not listed by taxonomy in Appendix II (Favre, 1989). Thus the number of Primates in Appendix II is inflated by this statement, for without this statement the number of Primates in Appendix II would only be 15 species greater than the expected number of Primates.

Also, Appendix III that provides extremely weak semi-international legal protections (Heijnsbergen, 1997) lists no Primates, but the expected number of Primates in Appendix III is approximately 33 species. The deviation from the expected number of Primates in Appendix III strongly supports the hypothesis, for a taxonomic group so genetically similar to Homo sapiens should not be provided with weak semi-international legal protections if the genetic similarity between Homo sapiens and Primates is proportional to the legal protections on Primates.

In short, the lack of deviation in Primates in Appendix I and the deviation in Primates in Appendix
Il do not refute the hypothesis. Despite the lack of deviation in Appendix I, significantly more Primates within Mammalia were listed in Appendix I than less related Mammalia species. Also, despite the deviation in Primates in Appendix II, all Primates were provided with international legal protections (Favre, 1989), for no Primates were listed in Appendix III. Therefore, Primates receive highly restrictive legal protections proportional to their genetic similarity to *Homo sapiens*.

As discussed earlier, comparing the number of species in one taxonomic group to the number of species in another taxonomic group is difficult, for different taxonomic groups have very different numbers of species (Futuyma, 2013). However, the results from Appendix I that compare the numbers of species in different taxonomic groups do strongly support the hypothesis. Despite Plantae species representing 80% of the species listed in CITES as a whole, the majority of species listed in Appendix I were Animalia species. Despite invertebrate species representing more species on Earth than vertebrate species (The IUCN Red List of Threatened Species, 2014), almost all the Animalia species listed in Appendix I were Chordata species. Despite the classes Aves, Amphibia, and Reptilia each containing more species on Earth than Mammalia, the majority of Chordata species in Appendix I were Mammalia species. In addition, while the order of Primates does contain a high number of species compared to other orders of Mammalia on Earth, the other orders of Mammalia when combined contain a far greater number of species, and yet the majority of Mammalia species in Appendix I were Primates. Animalia species represent a minority of the species listed in CITES, and Chordata, Mammalia, and Primate species represent a minority of the species living on Earth, and yet these species comprise the majority of Appendix I. Thus, there is strong evidence that kin selection is responsible for the unequal distribution of legal protections in CITES, for species closely related to *Homo sapiens* are consistently protected with highly restrictive legal protections proportional to their genetic similarity to *Homo sapiens*.

However, the numbers of species with a taxonomic group does not provide the whole picture, as seen in the case of the family Hominidae. *Homo sapiens* belong to the family Hominidae and while the
family Hominidae only represented a very small percentage of the Primates listed in Appendix I, these results still support the hypothesis, for all Hominidae species (excluding *Homo sapiens*) were listed in Appendix I. Thus, the species the most related to *Homo sapiens* in CITES are protected with the most restrictive legal protections in CITES, legal protections proportional to their genetic similarity to *Homo sapiens*.

The predictions made regarding the representation of Animalia, Chordata, Mammalia, Primates\(^\text{16}\), and Hominidae species in Appendix I were supported by results. Therefore, the genetic similarity between a species and *Homo sapiens* is proportional to the legal protections on that species, for taxonomic groups more related to *Homo sapiens* had significantly higher numbers of species (or in the case of Hominidae all members of the taxonomic group) listed in Appendix I than less related taxonomic groups. In CITES, there is a clear pattern of species highly related to *Homo sapiens* receiving highly restrictive legal protections, and thus the hypothesis that the unequal distribution of legal protections is a result of kin selection is strongly supported.

Appendix II

**Plantae**

Despite outward appearances, the large number of Plantae species listed in Appendix II does not refute the hypothesis. If the genetic similarity between a species and *Homo sapiens* is proportional to the legal protections on that species, then Plantae species (the species least related to *Homo sapiens* in CITES) should be protected with weak legal protections. As discussed earlier, Appendix II provides species with far less restrictive and therefore weaker legal protections than Appendix I, for Appendix II only prohibits trade in “exceptional cases”, while Appendix I only allows trade in “exceptional circumstances” (How CITES Works, 2012). Therefore, Appendix I should list significantly less Plantae species than Animalia species,

\(^{16}\)Excluding the prediction regarding the expected number of Primates in the chi square homogeneity of proportions test.
and Appendix II should primarily list species less related to *Homo sapiens*. As predicted, Appendix I listed significantly less Plantae species than Animalia species, and only 1% of Plantae species in CITES were listed in Appendix I. Also as predicted, Appendix II listed primarily Plantae species, and almost 99% of Plantae species in CITES were listed in Appendix II. Appendix II provides somewhat weak legal protections, and thus we would expect less related species (and even large numbers of less related species such as Plantae) to be listed in Appendix II. The distribution of Plantae species in Appendix I and Appendix II reveals Plantae as a kingdom is consistently given weak legal protections, and thus supports the hypothesis.

The kingdom of Plantae in CITES and especially in Appendix II lacks diversity, for the vast majority of species in Plantae belong to the order Orchidales. The number of Plantae species in Appendix II and in all of CITES is inflated\(^\text{17}\) by the order Orchidales, which contains approximately 25,384 species\(^\text{18}\). Thus, the large number of Plantae listed in CITES is a result of the large number of species within the order Orchidales. However, despite having the most species listed in CITES, the order Orchidales is not the most legal protected order in CITES. For example, only 0.39% of Orchidales species (100 species) were listed in Appendix I, while 34.76% of Primates (220 species) were listed in Appendix I. Therefore, the large numbers of Orchidales species in CITES does not refute the hypothesis, for the somewhat weak legal protections on Orchidales are roughly proportional to the genetic dissimilarity between Orchidales and *Homo sapiens*. Given the genetic dissimilarity between Plantae species and *Homo sapiens*, we would expect Plantae species to be protected with weak legal protections, and the large number of Plantae species in Appendix II supports this prediction and thus supports the hypothesis.

\(^{17}\) In fact, if the order Orchidales was not listed on CITES, the treaty as a whole would contain more Animalia species than Plantae species and Appendix II would contain more Animalia species than Plantae species.

\(^{18}\) The exact number of Orchidales species is unknown and the number of Orchidales species and varieties is an estimation (as of October 2, 2013) provided directly by CITES: [http://www.cites.org/sites/default/files/eng/disc/species_02.10.2013.pdf](http://www.cites.org/sites/default/files/eng/disc/species_02.10.2013.pdf).
Cnidaria and Aves

Similarly to Orchidales, large numbers of Cnidaria species were listed in Appendix II, for Cnidaria species comprised nearly 40% of the Animalia species in Appendix II. Given the genetic dissimilarity between Cnidaria species and *Homo sapiens*, we would expect Cnidaria species to be protected with weak legal protections, and this is what we observe in CITES. No Cnidaria species are listed in Appendix I as befitting their genetic dissimilarity to *Homo sapiens* and all Cnidaria species are listed in either Appendix II or Appendix III of CITES. Thus, Cnidaria species were protected with weak legal protections in CITES roughly proportional to their genetic similarity to *Homo sapiens*.

Similarly to Cnidaria, large numbers of Aves species\(^1\) were listed in Appendix II, and more Aves species were listed in Appendix II than Mammalia species. However, the large number of Aves species in Appendix II supports the hypothesis. In Appendix II, the number of Aves species exceeded the expected number\(^2\) of Aves species by approximately the same number of species that Aves was below the expected number of Aves species in Appendix I. Also, in Appendix II the number of Mammalia species was below the expected number of Mammalia species by approximately the same number of species that Mammalia exceeded the expected number of Mammalia species in Appendix I. The deviations from the expected number of Aves species reveals Aves species are primarily placed in Appendix II, primarily provided with weaker level of legal protections proportional to their genetic similarity to *Homo sapiens*. Conversely, while Mammalia deviated from the expected number of Mammalia species in Appendix I and Appendix II in the chi square homogeneity of proportions test, Mammalia did not deviate from the expected number

\(^1\) Similarly to Plantae, the class Aves lacks diversity. In Appendix II, Aves contained approximately twice as many species as Mammalia, however Aves only contained one more order than Mammalia. The discrepancy between the number of species and orders in Aves is because four Aves orders—Apodiformes, Falconiformes, Psittaciformes, and Strigiformes—out of the fifteen Aves orders contained almost 90% of the Aves species in Appendix II. While, these results have no bearing on the hypothesis, the high number of Orchidales and Aves species (especially Apodiformes and Psittaciformes species) listed in CITES may relate to a sensory bias of Homo sapiens (discussed in Interspecies Kin Selection and Other Byproducts).

\(^2\) The expected numbers referred to in this paragraph were generated from the chi square homogeneity of proportions test.
of Mammalia species if the number of Mammalia species in Appendix I and Appendix II was proportional to Mammalia’s genetic similarity to *Homo sapiens*. Given the weak legal protections provided by Appendix II (Favre, 1989), the strong legal protections provided by Appendix I, the genetic dissimilarity between Aves species and *Homo sapiens*, and the genetic similarity between Mammalia species and *Homo sapiens*, the legal protections on Aves and Mammalia species were proportional to their genetic similarity to *Homo sapiens*.

If the genetic similarity between a species and *Homo sapiens* is proportional to the legal protections on that species, then species less related to *Homo sapiens* such as Plantae, Aves, and Cnidaria species would be provided with less restrictive legal protections than species more related to *Homo sapiens*. Thus, these taxonomic groups should have higher numbers of species listed in Appendix II or Appendix III, and should have lower numbers of species listed in Appendix I. These predictions were supported by the results, so while the high numbers of Plantae, Aves, and Cnidaria species in Appendix II may seem to refute the hypothesis, the results actually support the hypothesis.

**Primates**

The majority of Primates were listed in Appendix II, and when viewed in isolation these results seem to refute the hypothesis. Primates are genetically very similar to *Homo sapiens* and since Appendix II provides far weaker legal protections than Appendix I (Favre, 1989), the genetic similarity between Primates and *Homo sapiens* appears not to be proportional to the legal protections on Primates. However, when the number of Primates in Appendix II is viewed in the context of CITES as a whole, the genetic similarity between Primates and *Homo sapiens* is proportional to the legal protections on Primates.

As predicted, all Primates were listed in Appendix I or in Appendix II and no Primates were listed.

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21 CITES specifically lists all Primates not listed in Appendix I in Appendix II, resulting in the following statement produced by the Animals Committee in 2012:

“A few scientists have seriously pointed out that - according to the official taxonomic mammal references -the current listing of PRIMATES spp. technically includes *Homo sapiens* as well. This is formally correct and no new situation as both former mammal references [HONACKI & al. (1982) and WILSON & REEDER (1992)] already placed *Homo sapiens* into the order Primates. According to the opinion of the
in Appendix III. While Appendix I provides stronger legal protections than Appendix II, both Appendix I and Appendix II provide uniform international legal protections\(^{22}\) and require a non-detrimental finding (Favre, 1989). Conversely, Appendix III does not provide uniform international legal protections and does not require a non-detrimental finding, and thus protects species with inherently weak semi-international legal protections. Therefore, the entire order of Primates was protected with international legal protections. The legal protections on Primates encompass the entire order and encompass the entire planet, therefore Primates are protected with legal protections proportional to their genetic similarity to *Homo sapiens*.

However, the legal protections on Orchidales encompass the entire order and encompass the entire planet as well, nevertheless, the legal protections provided to Orchidales and Primates were proportional to their respective genetic similarities to *Homo sapiens*. The key is Appendix I. As discussed earlier, 0.39% of Orchidales species (100 species) and 34.76% of Primates (220 species) were listed in Appendix I. Therefore, the large number of Primates in Appendix I reveals Primates as an order was protected with more restrictive legal protections than the order Orchidales, thus the legal protections provided to Orchidales and Primates was proportional to their respective genetic similarities to *Homo sapiens*. Likewise, the large number of Primates in Appendix I and the international legal protections on all Primate species reveals Primates as an order were protected with restrictive international legal protections proportional to their genetic similarity to *Homo sapiens*. In short, how CITES as whole protects the order of Primates strongly supports the hypothesis.

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\(^{22}\) CITES only protects species that are located in parties to the treaty, however, since 180 countries are party to the treaty (Member Countries, 2013), the legal protections in Appendix I and Appendix II can be characterized as “international” because only a small number of countries are not party to the treaty (Heijnsbergen, 1997).
Appendix III protects less than 200 species with very weak and inconsistent legal protections (Favre, 1989). Therefore, it was predicted Appendix III would not list any Hominidae or Primates species. This prediction was supported by the results, for all Hominidae and Primate species (excluding *Homo sapiens*) were listed in Appendix I and Appendix II, and thus were protected with far more restrictive legal protections than those provided by Appendix III. No other predictions regarding Appendix III were made, and while the distribution of species in Appendix III mirrors the distribution of species in Appendix I, these results have very little bearing on the hypothesis.

In Appendix III, almost all of the listed species were Animalia species, almost all of the listed Animalia species were Chordata species, and almost half of the listed Chordata species were Mammalia species. However, it is difficult to discern how the contents of Appendix III relate to the hypothesis. The majority of species listed in Appendix III are genetically similar to *Homo sapiens*, however Appendix III lists only 0.5% of the species listed in CITES. Therefore, the listing of 63 Mammalia species, 134 Chordata species, and 159 Animalia species in Appendix III does not invalidate the prediction that the genetic similarity between a species and *Homo sapiens* is proportional to the legal protections on that species, which is supported by the listing of 419 Mammalia species, 723 Chordata species, and 791 Animalia species in Appendix I. What species were listed in Appendix III does not relate to the hypothesis, but what species were not listed in Appendix III—namely no Hominidae and no Primate species—does relate and strongly support the hypothesis.

Summary of Findings

The hypothesis that the unequal distribution of legal protections on endangered species is a result of kin selection was supported by the analysis of the taxonomy of the species listed in CITES, for the genetic similarity between a species and *Homo sapiens* was proportional to the legal protections on that species. The strongest evidence for this hypothesis is the distribution of species in Appendix I. In Appendix
I, the majority of listed species were Animalia species, the majority of Animalia species were Chordata species, the majority of Chordata species were Mammalia species, and the majority of Mammalia species were Primates. Finally, all Hominidae species (excluding Homo sapiens) were listed in Appendix I. Additionally, the legal protections provided the order of Primates strongly supports the hypothesis, for all Primates were given international legal protections (i.e. listed in Appendix I or Appendix II). The species in Animalia, Chordata, Mammalia, Primates, and Hominidae are genetically similar to Homo sapiens, and thus Appendix I listed more Animalia, Chordata, Mammalia, and Primates species than genetically dissimilar species. As a result, Animalia, Chordata, Mammalia, Primates, and Hominidae were protected with highly restrictive legal protections in CITES, legal protections proportional to their genetic similarity to Homo sapiens.

The proportionality predicted by kin selection is most observable in Appendix I, for when the amount of aid is high—when legal protections are the most restrictive—the genetic similarity between the species and Homo sapiens is likewise high. However, when the amount of aid is less—when the legal protections are less restrictive—the proportionally predicted by kin selection is only generally observable. For example, the weak legal protections placed on species genetically dissimilar to Homo sapiens such as Plantae, Cnidaria, and Aves (which were primarily listed in Appendix II of CITES) were proportional to their genetic similarity to Homo sapiens. In Appendix I, there is a clear pattern of proportionality between genetic similarity to Homo sapiens and legal protections, while in Appendix II, there is only a general pattern of proportionality. However, the clear pattern of proportionality in Appendix I strongly supports the hypothesis that the unequal distribution of legal protections on endangered species is a result of kin selection, which has implications for CITES as well as the theory of kin selection.

Alternative Explanations

An alternative explanation for the unequal distribution of legal protections in CITES is the survival status of the listed species, for perhaps the species most related to Homo sapiens are also the most
endangered species on Earth. However, this is an explanation of how there is an unequal distribution of legal protections in CITES, and not an explanation of why there is an unequal distribution of legal protections in CITES. Thus, even if this explanation was true, the hypothesis would still be supported by the results.

As discussed earlier, how a species is listed in Appendix I is influenced by more than just the survival status of the species. First, the biological criteria for listing species in Appendix I are extremely vague (Favre, 1989) and the survival status of many endangered species is not fully known given the “imperfect knowledge” of conservation biology (Cox, 2007). Second, listing a species in Appendix I has substantial political and economic implications at both the international and domestic scales (Favre, 1989). Therefore, the decision to list a species in Appendix I is rife with uncertainty and political and economic drawbacks, and thus it is unlikely the survival status of endangered species is the sole proximate cause of the unequal distribution of legal protections in CITES. However, the proximate causes for listing a species in Appendix I explain how a species is listed, not why a species is listed, and thus have no bearing on the hypothesis.

This thesis analyzed why there was an unequal distribution of legal protections on endangered species, not how there was an unequal distribution of legal protections on endangered species. Therefore, this thesis analyzed the ultimate function of protecting endangered species, not the proximate causes of protecting endangered species. Thus, this thesis hypothesized the unequal distribution of legal protections on endangered species was a result of kin selection, for kin selection describes the ultimate function of behavior, not the proximate causes of behavior (Alcock, 2012). As a result, the multitude of potential proximate causes of listing endangered species in CITES, explanations of how there is an unequal distribution of legal protections on endangered species in CITES, had no bearing on the hypothesis.

Kin selection is not concerned with motivations but with end results (Alcock, 2012). For example, when a mother sacrifices her life for her child, kin selection is occurring regardless of her motivations—
the proximate causes—behind the sacrifice. Likewise, kin selection is occurring in CITES regardless of the motivations—the proximate causes—behind listing a species. Therefore, it does not matter if Hominidae species were listed in Appendix I because their life histories make them vulnerable to extinction (Heijnsbergen, 1997). It does not matter if a species was listed in Appendix II because of its economic worth (Favre, 1989). It does not matter if a species was listed in Appendix III because there was no political will to list it in Appendix I or Appendix II. What matters is that species closely related to *Homo sapiens* were provided with highly restrictive legal protections. What matters is the end results. Therefore, the hypothesis is unconnected with the survival status of Animalia, Chordata, Mammalia, Primates, and Hominidae species, but concerned with and strongly supported by the large numbers of these species listed in Appendix I.

Another alternative explanation for how there is an unequal distribution of legal protections in CITES is our knowledge of the survival status of the listed species (Shields, 2015). Perhaps the species most related to *Homo sapiens* are also the most studied species on Earth, and therefore are listed in Appendix I because we are aware they are endangered. While this explanation has no bearing on the hypothesis, if it is correct, it begs the question of why the species most related to *Homo sapiens* are the most studied species on Earth. The answer to this question could again be kin selection, and the proportionality predicted by kin selection could be extended to the amount of research conducted on a species and the amount of funding research on a species receives. For example, it could be predicted the genetic similarity between a species and *Homo sapiens* is proportional to the amount of research conducted on the species. Likewise, it could be predicted the genetic similarity between a species and *Homo sapiens* is proportional to the amount of funding research on the species receives. Thus, the proportionality predicted by kin

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23 Our knowledge of the survival status of the listed species is a potential proximate cause of how species are listed in Appendix I, and does not explain why species are listed in Appendix I. Therefore, our knowledge of the survival status of the listed species, like any other proximate cause, is unconnected to the hypothesis.
selection could be used to analyze the evolutionary roots of the many ways *Homo sapiens* interact with other species.

**Intrinsic or Genetic Worth?**

Wildlife conservation laws such as CITES (or rather Appendix I of CITES) are often lauded as “ecocentric” laws that recognize the “intrinsic worth” of non-*Homo sapiens*. If CITES was truly an ecocentric law, it would serve the interests of the “biotic community”, and it would value the needs of *Homo sapiens* no more than the needs of wildlife and ecosystems (Callicott, 1997). Conversely, if CITES was an anthropocentric law, it would serve the interests of *Homo sapiens*, and it would value the needs of *Homo sapiens* over the needs of wildlife and ecosystems (Anthropocentric). Therefore, if a law was influenced by kin selection, it would be an anthropocentric law.

Kin selection is a selfish behavior, for it primarily benefits the organism performing the behavior (Alcock, 2012), and thus a law influenced by kin selection would primarily benefit its creators—*Homo sapiens*. Therefore, given the strong evidence that the unequal distribution of legal protections in CITES is a result of kin selection, CITES is an anthropocentric law. CITES increases the indirect fitness of *Homo sapiens* by placing restrictive legal protections on species more genetically similar to *Homo sapiens*, and thus serves the selfish interests of *Homo sapiens*. As a result, CITES is not an “ecocentric” law that recognizes the “intrinsic worth” of non-*Homo sapiens* (Callicott, 1997), but an anthropocentric law that recognizes the “intrinsic worth” of non-*Homo sapiens*.

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24 An ecocentric perspective adheres to Aldo Leopold’s “Land Ethic” where “a thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community” (1949). The “biotic community” encompasses every part of the natural environment and under this ethic every member of the “biotic community” has intrinsic worth (Callicott, 1997). An ecocentric perspective places *Homo sapiens* in the humble position of being just another member of the “biotic community” and values the wellbeing of the “biotic community” over the selfish interests of *Homo sapiens*.

25 Intrinsic worth refers to the value an entity has independent of its economic utility to *Homo sapiens* (Callicott, 1997).

26 Anthropocentric is defined by Merriam-Webster as “considering human beings as the most significant entity of the universe” (Anthropocentric) and is often referred to as a human-centered worldview (Callicott, 1997).
recognizes the “genetic worth”\textsuperscript{27} non-\textit{Homo sapiens} have in increasing the indirect fitness of \textit{Homo sapiens} (Alcock, 2012). CITES is not a form of ecological altruism, but CITES is selfish.

If it was hypothesized that CITES is an anthropocentric law, then it could be predicted the genetic similarity between a species and \textit{Homo sapiens} is proportional to the legal protections on that species. Conversely, if it was hypothesized that CITES is an ecocentric law, then it could be predicted each taxonomic group would be equally represented in CITES\textsuperscript{28}. For example, it could be predicted Plantae and Animalia would list the same number of species in Appendix I, for Plantae and Animalia species are equally important members of the “biotic community” (Leopold, 1949). The hypothesis that CITES is an ecocentric law was tested in this thesis, for the null hypothesis in the chi square goodness of fit test was that each taxonomic group would be equally represented in CITES. However, the null hypothesis was rejected at the kingdom, phylum, and class level in all three appendices. Additionally, the null hypothesis was rejected at the order level of Appendix I and Appendix II\textsuperscript{29}. Thus, the hypothesis that CITES is an ecocentric law, can be rejected, for not only is there strong evidence that CITES is an anthropocentric law, which favors species more related to \textit{Homo sapiens}, but there is also strong evidence against CITES treating each species equally as a member of the “biotic community”.

\textsuperscript{27} CITES specifically states species are conserved for non-economic values such as scientific, aesthetic, cultural, and recreational values (Heijnsbergen, 1997, p. 56). However, given the influence of kin selection in CITES, perhaps CITES should add “genetic value” to this list like the Protocol Agreement on the Conservation of Common Natural Resources (which contained provisions relating to CITES) did. This agreement recognized “the increasing values of the world fauna and flora with regard to their ecologic, genetic, scientific, social, economic, cultural, educational and recreational aspects” (Treaties: Record Details). In the context of this agreement “genetic...aspects” most likely referred to values associated with biodiversity, however, is it not ironic that an agreement that could be lauded as “ecocentric” specifically mentions what makes the agreement anthropocentric—recognizing the genetic worth that species have to \textit{Homo sapiens}?

\textsuperscript{28} While different taxonomic groups contain very different numbers of species, at the large levels of the kingdom, phylum, class, and order it is possible for these groups to have approximately equal numbers of species. Also, to overcome any error that might be introduced by very different numbers of species in each group, a very low $\alpha$ value of 0.001 was used to assess the statistical significance of the chi square goodness of fit test.

\textsuperscript{29} The chi square goodness of fit test was not performed on the orders of Mammalia species listed in Appendix III because no Primates were listed in Appendix III.
Interspecies Kin Selection and Other Byproducts

The evidence indicates the genetic similarity between a species and *Homo sapiens* is proportional to the legal protections on that species, and thus strongly supports the hypothesis that the unequal distribution of legal protections on endangered species is a result of kin selection. In essence, this thesis has found evidence of kin selection influencing the interactions between *Homo sapiens* and other species, and thus has found evidence of interspecies kin selection. Interspecies kin selection in CITES does increase the fitness of *Homo sapiens* by increasing the frequency of alleles (or rather preventing the loss of alleles) that *Homo sapiens* share with other Hominidae, Primates, Mammalia, Chordata, and Animalia species. However, interspecies kin selection is most likely a byproduct of interspecies kin selection.

Interspecies kin selection is highly adaptive, and thus *Homo sapiens* have the ability to recognize different levels of kin from the closest level of the immediate family to evermore distant levels of kin such as the ethnic group, the race, and the species (Krupp, DeBruine, Jones, & Lalumiere, 2012). Kin recognition is facilitated by facial phenotype, and thus certain facial phenotypes (such as the large head, big eyes, and round cheeks associated with Kindchenschema [Lorenz, 1943]) trigger certain highly adaptive behaviors (such as cooperation) (DeBruine, Jones, Little, & Perrett, 2008). Thus, when other closely related species possess facial phenotypes similar to the facial phenotypes of *Homo sapiens*, the same adaptive response is triggered (Alvergne, et al., 2009). Thus, the ability of *Homo sapiens* to recognize kin outside of our species is a byproduct of a visual system attuned to interspecies kin recognition, and cooperative behaviors between *Homo sapiens* and other closely related species are byproducts of a behavioral system primed to cooperate with interspecies kin. Interspecies kin selection is a byproduct of interspecies kin selection, but that does not make interspecies kin selection any less adaptive or any less of a reality.

CITES may not only be influenced by the byproducts of interspecies kin selection, but also by the

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30 Interspecies kin recognition facilitated solely by facial phenotype has been observed between *Homo sapiens* and other Primates (Alvergne, et al., 2009).
byproducts *Homo sapiens' visual systems. While the large numbers of Plantae species (especially Orchidales), and Aves species listed in CITES does not refute the hypothesis that the unequal distribution of legal protections on endangered species is a result of kin selection, these numbers require an explanation. Why are these species listed in CITES? Why is international trade in Orchidales and Aves species, especially Apodiformes species (hummingbirds and swifts [Myers, “Apodiformes”, 2015]) and Psittaciformes species (parrots [Myers, “Psittaciformes”, 2015]) (which have the highest number of species in Aves), such a concern to the Conference of Parties? Why are these species traded so heavily to begin with? Perhaps the answers to these questions about the listing of Orchidales and Aves species, lies in experiments performed on Aves species.

There is evidence in Australian grassfinches that sexual selection is driven by a sensory bias of the female (Burley & Symanski, 1998). This sensory bias favors certain phenotypes over others and is thought to be a byproduct of an otherwise adaptive behavior. For example, the sensory bias may favor a particular color because that color is the color of the species’ source of food, shelter, or some other basic need (Coyne, 2009). Applying these results to *Homo sapiens*, perhaps the vibrantly colored Orchidales, Apodiformes, and Psittaciformes species listed in CITES are legal protected and internationally traded because *Homo sapiens* have a sensory bias that favors the vibrant colors of these species. Perhaps seeking out vibrantly colored objects is adaptive in some way, or (more likely) the complex visual system of *Homo sapiens* favors certain colors over others. The visual system of *Homo sapiens* confers a large fitness benefit, and perhaps the same visual system that allows *Homo sapiens* to recognize kin, avoid danger, and find food (Alcock, 2012), also favors certain colors as a byproduct of its structure. So while Animalia, Chordata, Mammalia, Primates, and Hominidae species are listed in CITES because of interspecies kin selection, a byproduct of intraspecies kin selection, perhaps Orchidales and Aves species are listed on CITES because of a sensory bias of *Homo sapiens*, a byproduct of an adaptive visual system.
Interspecies Cooperation and Kin Selection

CITES can be characterized as interspecies cooperation\(^{31}\) between *Homo sapiens* and other species. The species protected in CITES receive a benefit by being listed, for CITES only allows trade in Appendix I and Appendix II species when there has been a non-detrimental finding (Favre, 1989). Also, *Homo sapiens* receive a benefit by listing species in CITES, for CITES places the most restrictive legal protections on species more related to *Homo sapiens* and thus CITES increases the indirect fitness of *Homo sapiens*. Therefore, CITES is an example of interspecies cooperation, for both *Homo sapiens* and the listed species are receiving a benefit from CITES. Also, given that interspecies kin selection influences what species are listed in CITES, CITES is an example of interspecies cooperation that can be explained by interspecies kin selection.

Interspecies cooperation is often explained through reciprocal altruism, and kin selection is never examined as an explanation of interspecies cooperation (Trivers, 1971). However, this thesis has found evidence of interspecies kin selection influencing interspecies cooperation. While the findings of this thesis likely have limited applicability, for interspecies kin selection likely only influences interspecies cooperation involving *Homo sapiens*, interspecies kin selection does occur. All life is kin, therefore interspecies kin selection is theoretically possible, and therefore the possibility of interspecies kin selection should be assessed when attempting to explain interspecies cooperation. The explanatory power of kin selection should not be limited to intraspecies interactions, for as this thesis has shown, kin selection has great explanatory power when it comes to interspecies interactions.

\(^{31}\) Cooperation is defined by Dictionary.com as an “activity shared for mutual benefit” (Cooperation).
Conclusion

“We worry more about how we treat animals. None of this has anything to do with evolution...”
(Coyne, 2009, p. 230)

How we treat animals—how we legally protect them—does have something to do with evolution, for as this thesis has shown, how we treat animals is influenced by kin selection. The hypothesis that the unequal distribution of legal protections on endangered species is a result of kin selection was supported by the analysis of CITES, for species genetically similar to Homo sapiens were provided with highly restrictive legal protections proportional to their high degree of genetic similarity to Homo sapiens. The touch of nature, or rather the touch of natural selection, has made the whole world kin, and thus the explanatory power of kin selection should not be limited to intraspecies interactions, but should be extended to interspecies interactions. Thus, the explanatory power of evolution should not be limited to rudimentary human behaviors, but should be extended to our most complex behaviors.
Bibliography


*Cooperation*. (n.d.). Retrieved from Dictionary.com:
http://dictionary.reference.com/browse/cooperation


The Total Number of Animalia and Plantae Species Listed in the Three Appendices of CITES

Animalia 17%
Plantae 83%

Figure 1: The Total Number of Animalia and Plantae Species Listed in the Three Appendices of CITES
This pie chart compares the number of species in the kingdoms Animalia and Plantae listed in the three appendices of CITES. There were 6262 Animalia species and 30355 Plantae species listed in CITES.
Figure 2: The Total Number of Species in the Phyla of Animalia Listed in the Three Appendices of CITES

This pie chart compares the number of species in the phyla of Animalia listed in the three appendices of CITES. There were 3966 Chordata species, 2108 Cnidaria species, 104 Arthropoda species, 81 Mollusca species, two Annelida species, and one Echinodermata species listed in CITES.
Figure 3: The Total Number of Species in the Classes of Chordata Listed in the Three Appendices of CITES

This pie chart compares the number of species in the classes of Chordata listed in the three appendices of CITES. There were 90 Actinopterygii species, 169 Amphibia species, 1636 Aves species, 17 Elasmobranchii species, 1195 Mammalia species, 856 Reptilia species, and three Sarcopterygii species listed in CITES.
The Total Number of Species in the Orders of Mammalia Listed in the Three Appendices of CITES

Figure 4: The Total Number of Species in the Orders of Mammalia Listed in the Three Appendices of CITES

This pie chart compares the number of species in the orders of Mammalia listed in the three appendices of CITES. There were 102 Artiodactyla species, 181 Carnivora species, 94 Cetacea species, 71 Chiroptera species, four Cingulata species, two Dasyuromorphia species, 16 Diprotodontia species, two Lagomorpha species, three Monotremata species, two Peramelemorphia species, 27 Perissodactyla species, eight Pholidota species, five Pilosa species, 633 Primates, three Proboscidea species, 18 Rodentia species, 20 Scandentia species, and four Sirenia species in CITES.
Figure 5: Comparison of the Number of Species in Animalia and Plantae in Appendix I of CITES

This pie chart compares the number of Animalia and Plantae species listed in Appendix I of CITES. There were 791 Animalia species and 366 Plantae species listed in Appendix I.
Figure 6: Comparison of the Number of Orders in Animalia and Plantae in Appendix I of CITES

This pie chart compares the number of orders in the kingdoms Animalia and Plantae in Appendix I of CITES. There were 52 Animalia orders and 13 Plantae orders in Appendix I.
Figure 7: Comparison of the Number of Species in the Phyla of Animalia in Appendix I of CITES
This pie chart compares the number of species in the phyla of Animalia in Appendix I of CITES. There were three Arthropoda species, 723 Chordata species, and 65 Mollusca species listed in Appendix I.
Figure 8: Comparison of the Number of Orders in the Phyla of Animalia in Appendix I of CITES
This pie chart compares the number of orders in the phyla of Animalia in Appendix I of CITES. There were 49 Chordata orders, one Arthropoda order, and two Mollusca orders in Appendix I.
Figure 9: Comparison of the Number of Species in the Classes of Chordata in Appendix I of CITES

This pie chart compares the number of species in the classes of Chordata in Appendix I of CITES. There were seven Actinopterygii species, 24 Amphibia species, 164 Aves species, seven Elasmobranchii species, 419 Mammalia species, 100 Reptilia species, and two Sarcopterygii species in CITES.
Figure 10: Comparison of the Number of Orders in the Classes of Chordata in Appendix I of CITES
This pie chart compares the number of orders in the classes of Chordata in Appendix I of CITES. There were six Actinopterygii orders, two Amphibia orders, 21 Aves orders, one Elasmobranchii order, 14 Mammalia orders, five Reptilia orders, and one Sarcopterygii order in CITES.
**Figure 11: Comparison of the Number of Species in the Orders of Mammalia in Appendix I of CITES**

This pie chart compares the number of species in the orders of Mammalia listed in Appendix I of CITES. There were 58 Artiodactyla species, 48 Carnivora species, 32 Cetacea species, 11 Chiroptera species, one Cingulata species, two Dasyuromorphia species, eight Diprotodontia species, two Lagomorpha species, two Peramelemorphia species, 22 Perissodactyla species, 220 Primates, two Proboscidea species, seven Rodentia species, and four Sirenia species in CITES.
Figure 12: Comparison of the Number of Species in the Families of Primates in Appendix I of CITES

This pie chart compares the number of species in the families of Primates listed in Appendix I of CITES. There were eight Atelidae species, 13 Cebidae species, 35 Cercopithecidae species, 34 Cheirogaleidae species, one Daubentoniidae species, six Hominidae species, 31 Hylobatidae species, 24 Indriidae species, 26 Lemuridae species, 26 Lepilemuridae species, eight Lorisidae species, and eight Pitheciidae species listed in CITES.
Figure 13: Comparison of the Number of Species in Animalia and Plantae in Appendix II of CITES

This pie chart compares the number of Animalia and Plantae species listed in Appendix II of CITES. There were 5312 Animalia species and 29974 Plantae species listed in Appendix II.
Figure 14: Comparison of the Number of Orders in Animalia and Plantae in Appendix II of CITES

This pie chart compares the number of Animalia and Plantae orders listed in Appendix II of CITES. There were 62 Animalia orders and 29 Plantae orders in Appendix II.
Comparison of the Number of Species in the Phyla of Animalia in Appendix II of CITES

Annelida, 0.04%
Arthropoda, 1.52%
Chordata, 58.53%
Cnidaria, 39.61%
Mollusca, 0.30%

Figure 15: Comparison of the Number of Species in the Phyla of Animalia in Appendix II of CITES
This pie chart compares the number of species in the phyla of Animalia in Appendix II of CITES. There were two Annelida species, 81 Arthropoda species, 3109 Chordata species, 2104 Cnidaria species, and 16 Mollusca species listed in Appendix II.
Figure 16: Comparison of the Number of Orders in the Phyla of Animalia in Appendix II of CITES

This pie chart compares the number of species in the phyla of Animalia in Appendix II of CITES. There were four Arthropoda orders, one Annelida order, 46 Chordata orders, six Cnidaria orders, and five Mollusca orders in Appendix II.
Figure 17: Comparison of the Number of Species in the Classes of Chordata in Appendix II of CITES
This pie chart compares the number of species in the classes of Chordata in Appendix II of CITES. There were 83 Actinopterygii species, 142 Amphibia species, 1444 Aves species, ten Elasmobranchii species, 713 Mammalia species, 716 Reptilia species, and one Sarcopterygii species in Appendix II.
Figure 18: Comparison of the Number of Orders in the Classes of Chordata in Appendix II of CITES
This pie chart compares the number of orders in the classes of Chordata in Appendix II of CITES. There were six Actinopterygii orders, two Amphibia orders, 15 Aves orders, four Elasmobranchii orders, 14 Mammalia orders, four Reptilia orders, and one Sarcopterygii order in Appendix II.
Figure 19: Comparison of the Number of Species in the Orders of Mammalia in Appendix II of CITES
This pie chart compares the number of species in the orders of Mammalia listed in Appendix II of CITES. There were 31 Artiodactyla species, 95 Carnivora species, 62 Cetacea species, 59 Chiroptera species, one Cingulata species, eight Diprotodontia species, five Perissodactyla species, eight Pholidota, three Pilosa, 413 Primates, one Proboscidea species, four Rodentia species, and 20 Scandentia species in Appendix II.
Figure 20: Comparison of the Number of Species in Animalia and Plantae in Appendix III of CITES

This pie chart compares the number of Animalia and Plantae species listed in Appendix III of CITES. There were 159 Animalia species and 15 Plantae species listed in Appendix II.
Comparison of the Number of Orders in Animalia and Plantae in Appendix III of CITES

Animalia 71%
Plantae 29%

Figure 21: Comparison of the Number of Orders in Animalia and Plantae in Appendix III of CITES
This pie chart compares the number of Animalia and Plantae orders in Appendix III of CITES. There were 22 Animalia orders and 9 Plantae orders in Appendix II.
Figure 22: Comparison of the Number of Species in the Phyla of Animalia in Appendix III of CITES

This pie chart compares the number of species in the phyla of Animalia in Appendix III of CITES. There were 20 Arthropoda species, 134 Chordata species, 4 Cnidaria species, and one Echinodermata species listed in Appendix III.
Figure 23: Comparison of the Number of Orders in the Phyla of Animalia in Appendix III of CITES
This pie chart compares the number of orders in the phyla of Animalia in Appendix III of CITES. There were two Arthropoda orders, 18 Chordata orders, one Cnidaria order, and one Echinodermata order in Appendix III.
Figure 24: Comparison of the Number of Species in the Classes of Chordata in Appendix III of CITES

This pie chart compares the number of species in the classes of Chordata in Appendix III of CITES. There were three Amphibia species, 28 Aves species, 63 Mammalia species, and 40 Reptilia species in Appendix III.
Figure 25: Comparison of the Number of Orders in the Classes of Chordata in Appendix III of CITES

This pie chart compares the number of orders in the classes of Chordata in Appendix III of CITES. There were two Amphibia orders, seven Aves orders, six Mammalia orders, and three Reptilia orders in Appendix III.
Appendix A: Tables

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<th>Chi Square Test for Independence for the Appendix of CITES a Species was listed in and the Species' Taxonomic Classification</th>
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<tr>
<td>Degrees of Freedom</td>
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<td>P-value</td>
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*Table 1: Chi Square Test for Independence for the Appendix of CITES a Species was listed in and the Species' Taxonomic Classification*

This table shows the results of the chi square test for independence. As the table shows, there was an association between the kingdom, phylum, class, and order a species belonged to and the appendix of CITES the species was listed in.
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*Table 2: The Observed and Expected Number of Species in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES for the Chi Square Goodness of Fit Test*

This table shows the observed and expected number of species in Animalia and Plantae in the three appendices of CITES. The expected number of species is the number of species expected if each kingdom was represented equally in CITES.
Chi Square Goodness of Fit Test for the Number of Species in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES

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Table 3: Chi Square Goodness of Fit Test for the Number of Species in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES

This table shows the results of the chi square goodness of fit test. As the table shows, the kingdoms of Animalia and Plantae were not represented equally in the three appendices of CITES.
The Observed and Expected Number of Species in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES for the Chi Square Homogeneity of Proportions Test

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Table 4: The Observed and Expected Number of Species in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES for the Chi Square Homogeneity of Proportions Test

This table shows the observed and expected numbers of species in Animalia and Plantae in the three appendices of CITES. The expected number of species is the number of species expected if the number of species in each kingdom within one appendix was proportional to the total number of species in each kingdom in all of CITES and the size of one appendix.
This table shows the results of the chi square homogeneity of proportions test. As the table shows, the numbers of Animalia and Plantae species were not proportional to their representation in all of CITES and the size of each appendix.

| Chi Square Homogeneity of Proportions Test for the Number of Species in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES |
|--------------------------------------------------|-----------------|-----------------|
| Chi Squared Value                                | Appendix I      | Appendix II     | Appendix III    |
| 2144.86                                          | 104.32          | 677.16          |
| Degrees of Freedom                               | 1               | 1               | 1               |
| P-value                                          | p<0.0001        | p<0.0001        | p<0.0001        |

*Table 5: Chi Square Homogeneity of Proportions Test for the Number of Species in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES*
The Observed and Expected Number of Orders in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES for the Chi Square Goodness of Fit Test

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<th>Appendix II</th>
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<tr>
<td>Animalia</td>
<td>52</td>
<td>32.5</td>
<td>62</td>
</tr>
<tr>
<td>Plantae</td>
<td>13</td>
<td>32.5</td>
<td>29</td>
</tr>
</tbody>
</table>

*Table 6: The Observed and Expected Number of Orders in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES for the Chi Square Goodness of Fit Test*

This table shows the observed and expected numbers of orders in Animalia and Plantae in the three appendices of CITES. The expected number of orders is the number of orders expected if each kingdom was equally diverse in CITES.
<table>
<thead>
<tr>
<th>Chi Square Goodness of Fit Test for the Number of Orders in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES</th>
<th>Appendix I</th>
<th>Appendix II</th>
<th>Appendix III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared Value</td>
<td>23.40</td>
<td>11.97</td>
<td>5.45</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>P-value</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.001</td>
<td>p&gt;0.001</td>
</tr>
</tbody>
</table>

*Table 7: Chi Square Goodness of Fit Test for the Number of Orders in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES*

This table shows the results of the chi square goodness of fit test. As the table shows, the kingdoms of Animalia and Plantae were not equally diverse in Appendix I and Appendix II.
The Observed and Expected Number of Orders in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES for the Chi Square Homogeneity of Proportions Test

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Appendix I</th>
<th>Appendix II</th>
<th>Appendix III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed</td>
<td>Expected</td>
<td>Observed</td>
</tr>
<tr>
<td></td>
<td>Number of</td>
<td>Number of</td>
<td>Number of</td>
</tr>
<tr>
<td></td>
<td>Orders</td>
<td>Orders</td>
<td>Orders</td>
</tr>
<tr>
<td>Animalia</td>
<td>52</td>
<td>47</td>
<td>62</td>
</tr>
<tr>
<td>Plantae</td>
<td>13</td>
<td>18</td>
<td>29</td>
</tr>
</tbody>
</table>

This table shows the observed and expected numbers of orders in Animalia and Plantae in the three appendices of CITES. The expected number of orders is the number of orders expected if the number of orders in each kingdom within an appendix was proportional to the total number of orders in each kingdom in all of CITES and the total number of orders within that appendix.
Chi Square Homogeneity of Proportions Test for the Number of Orders in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES

<table>
<thead>
<tr>
<th></th>
<th>Appendix I</th>
<th>Appendix II</th>
<th>Appendix III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared Value</td>
<td>1.73</td>
<td>0.97</td>
<td>0.05</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>P-value</td>
<td>p&gt;0.001</td>
<td>p&gt;0.001</td>
<td>p&gt;0.001</td>
</tr>
</tbody>
</table>

*Table 9: Chi Square Homogeneity of Proportions Test for the Number of Orders in Animalia and Plantae in Appendix I, Appendix II, and Appendix III of CITES*

This table shows the results of the chi square homogeneity of proportions test. As the table shows, the numbers of Animalia and Plantae orders did not deviate significantly from the expected numbers of Animalia and Plantae orders.
The Observed and Expected Number of Species in the Phyla of Animalia in Appendix I of CITES for the Chi Square Goodness of Fit Test

<table>
<thead>
<tr>
<th>Phylum</th>
<th>Observed Number of Species</th>
<th>Expected Number of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthropoda</td>
<td>3</td>
<td>263.67</td>
</tr>
<tr>
<td>Chordata</td>
<td>723</td>
<td>263.67</td>
</tr>
<tr>
<td>Mollusca</td>
<td>65</td>
<td>263.67</td>
</tr>
</tbody>
</table>

This table shows the observed and expected numbers of species in the phyla of Animalia in Appendix I of CITES. The expected number of species is the number of species expected if each phylum was represented equally in CITES.

Table 10: The Observed and Expected Number of Species in the Phyla of Animalia in Appendix I of CITES for the Chi Square Goodness of Fit Test
Chi Square Goodness of Fit Test for the Number of Species in the Phyla of Animalia in Appendix I, Appendix II, and Appendix III of CITES

<table>
<thead>
<tr>
<th></th>
<th>Appendix I</th>
<th>Appendix II</th>
<th>Appendix III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared Value</td>
<td>1207.60</td>
<td>7959.38</td>
<td>303.21</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>P-value</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
</tr>
</tbody>
</table>

*Table 11: Chi Square Goodness of Fit Test for the Number of Species in the Phyla of Animalia in Appendix I, Appendix II, and Appendix III of CITES*

This table shows the results of the chi square goodness of fit test. As the table shows, the phyla of Animalia were not represented equally in the three appendices of CITES.
The Observed and Expected Number of Species in the Phyla of Animalia in Appendix I, Appendix II, and Appendix III of CITES for the Chi Square Homogeneity of Proportions Test

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Appendix I</th>
<th>Appendix II</th>
<th>Appendix III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed Number of Species</td>
<td>Expected Number of Species</td>
<td>Observed Number of Species</td>
</tr>
<tr>
<td>Annelida, Arthropoda, Echinodermata, and Mollusca</td>
<td>68</td>
<td>23.75</td>
<td>97</td>
</tr>
<tr>
<td>Chordata</td>
<td>723</td>
<td>500.98</td>
<td>3109</td>
</tr>
<tr>
<td>Cnidaria</td>
<td>0</td>
<td>266.28</td>
<td>2104</td>
</tr>
</tbody>
</table>

*Table 12: The Observed and Expected Number of Species in the Phyla of Animalia in Appendix I, Appendix II, and Appendix III of CITES for the Chi Square Homogeneity of Proportions Test*

This table shows the observed and expected number of species in the phyla of Animalia in the three appendices of CITES. The expected number of species is the number of species expected if the number of species in each phylum within an appendix was proportional to the total number of species in each phylum in all of CITES and the total number of species protected within that appendix.
### Chi Square Homogeneity of Proportions Test for the Number of Species in the Phyla of Animalia in Appendix I, Appendix II, and Appendix III of CITES

<table>
<thead>
<tr>
<th></th>
<th>Appendix I</th>
<th>Appendix II</th>
<th>Appendix III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared Value</td>
<td>447.14</td>
<td>98.72</td>
<td>108.45</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>P-value</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
</tr>
</tbody>
</table>

*Table 13: Chi Square Homogeneity of Proportions Test for the Number of Species in the Phyla of Animalia in Appendix I, Appendix II, and Appendix III of CITES*

This table shows the results of the chi square homogeneity of proportions test. As the table shows, the number of species in the phyla of Animalia were not proportional to their representation in all of CITES and the size of each appendix.
### The Observed and Expected Number of Orders in the Phyla of Animalia in Appendix I of CITES for the Chi Square Goodness of Fit Test

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Appendix I</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed Number of Orders</td>
</tr>
<tr>
<td>Arthropoda</td>
<td>1</td>
</tr>
<tr>
<td>Chordata</td>
<td>49</td>
</tr>
<tr>
<td>Mollusca</td>
<td>2</td>
</tr>
</tbody>
</table>

*Table 14: The Observed and Expected Number of Orders in the Phyla of Animalia in Appendix I of CITES for the Chi Square Goodness of Fit Test*

This table shows the observed and expected numbers of orders in the phyla of Animalia in Appendix I of CITES. The expected number of orders is the number of orders expected if each phylum was equally diverse in CITES.
Chi Square Goodness of Fit Test for the Number of Orders in the Phyla of Animalia in Appendix I, Appendix II, and Appendix III of CITES

<table>
<thead>
<tr>
<th></th>
<th>Appendix I</th>
<th>Appendix II</th>
<th>Appendix III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared Value</td>
<td>86.81</td>
<td>114.94</td>
<td>38.00</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>P-value</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.001</td>
<td>P&lt;0.001</td>
</tr>
</tbody>
</table>

Table 15: Chi Square Goodness of Fit Test for the Number of Orders in the Phyla of Animalia in Appendix I, Appendix II, and Appendix III of CITES

This table shows the results of the chi square goodness of fit test. As the table shows, the phyla of Animalia were not equally diverse in the three appendices of CITES.
The Observed and Expected Number of Species in the Classes of Chordata in Appendix I of CITES for the Chi Square Goodness of Fit Test

<table>
<thead>
<tr>
<th>Class</th>
<th>Observed Number of Species</th>
<th>Expected Number of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actinopterygii</td>
<td>7</td>
<td>103.29</td>
</tr>
<tr>
<td>Amphibia</td>
<td>24</td>
<td>103.29</td>
</tr>
<tr>
<td>Aves</td>
<td>164</td>
<td>103.29</td>
</tr>
<tr>
<td>Elasmobranchii</td>
<td>7</td>
<td>103.29</td>
</tr>
<tr>
<td>Mammalia</td>
<td>419</td>
<td>103.29</td>
</tr>
<tr>
<td>Reptilia</td>
<td>100</td>
<td>103.29</td>
</tr>
<tr>
<td>Sarcopterygii</td>
<td>2</td>
<td>103.29</td>
</tr>
</tbody>
</table>

Table 16: The Observed and Expected Number of Species in the Classes in Chordata in Appendix I of CITES for the Chi Square Goodness of Fit Test

This table shows the observed and expected number of species the Classes in Chordata in Appendix I of CITES. The expected number of species is the number of species expected if each class in Chordata was represented equally in Appendix I.
Chi Square Goodness of Fit Test for the Number of Species in the Classes of Chordata in Appendix I, Appendix II, and Appendix III of CITES

<table>
<thead>
<tr>
<th></th>
<th>Appendix I</th>
<th>Appendix II</th>
<th>Appendix III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared Value</td>
<td>1340.55</td>
<td>3945.75</td>
<td>55.91</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>6</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>P-value</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
</tr>
</tbody>
</table>

*Table 17: Chi Square Goodness of Fit Test for the Number of Species in the Classes of Chordata in Appendix I, Appendix II, and Appendix III of CITES*

This table shows the results of the chi square goodness of fit test. As the table shows, the classes of Chordata were not represented equally in the three appendices of CITES.
### Table 18: The Observed and Expected Number of Species in the Classes of Chordata in Appendix I, Appendix II, and Appendix III of CITES for the Chi Square Homogeneity of Proportions Test

<table>
<thead>
<tr>
<th>Class</th>
<th>Appendix I</th>
<th>Expected Number of Species</th>
<th>Appendix II</th>
<th>Expected Number of Species</th>
<th>Appendix III</th>
<th>Expected Number of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actinopterygii, Elasmobranchii, and Sarcopterygii</td>
<td>16</td>
<td>20</td>
<td>18</td>
<td>30</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Amphibia</td>
<td>24</td>
<td>31</td>
<td>142</td>
<td>132</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Aves</td>
<td>164</td>
<td>298</td>
<td>1444</td>
<td>1282</td>
<td>28</td>
<td>55</td>
</tr>
<tr>
<td>Mammalia</td>
<td>419</td>
<td>218</td>
<td>713</td>
<td>937</td>
<td>63</td>
<td>40</td>
</tr>
<tr>
<td>Reptilia</td>
<td>100</td>
<td>156</td>
<td>716</td>
<td>671</td>
<td>40</td>
<td>29</td>
</tr>
</tbody>
</table>

This table shows the observed and expected numbers of species in the classes of Chordata in the three appendices of CITES. The expected number of species is the number of species expected if the number of species in each class within an appendix was proportional to the total number of species in each class in all of CITES and the total number of species protected within that appendix.
### Chi Square Homogeneity of Proportions Test for the Number of Species in the Classes of Chordata in Appendix I, Appendix II, and Appendix III of CITES

<table>
<thead>
<tr>
<th></th>
<th>Appendix I</th>
<th>Appendix II</th>
<th>Appendix III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared Value</td>
<td>268.43</td>
<td>78.71</td>
<td>35.28</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>P-value</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
</tr>
</tbody>
</table>

*Table 19: Chi Square Homogeneity of Proportions Test for the Number of Species in the Classes of Chordata in Appendix I, Appendix II, and Appendix III of CITES*

This table shows the results of the chi square homogeneity of proportions test. As the table shows, the numbers of species in the classes of Chordata were not proportional to their representation in all of CITES and the size of each appendix.
### The Observed and Expected Number of Orders in the Classes of Chordata in Appendix I of CITES for the Chi Square Goodness of Fit Test

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Observed Number of Orders</th>
<th>Expected Number of Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actinopterygii</td>
<td>6</td>
<td>7.14</td>
</tr>
<tr>
<td>Amphibia</td>
<td>2</td>
<td>7.14</td>
</tr>
<tr>
<td>Aves</td>
<td>21</td>
<td>7.14</td>
</tr>
<tr>
<td>Elasmobranchii</td>
<td>1</td>
<td>7.14</td>
</tr>
<tr>
<td>Mammalia</td>
<td>14</td>
<td>7.14</td>
</tr>
<tr>
<td>Reptilia</td>
<td>5</td>
<td>7.14</td>
</tr>
<tr>
<td>Sarcopterygii</td>
<td>1</td>
<td>7.14</td>
</tr>
</tbody>
</table>

*Table 20: The Observed and Expected Number of Orders in the Classes of Chordata in Appendix I of CITES for the Chi Square Goodness of Fit Test*

This table shows the observed and expected numbers of orders in the classes of Chordata in Appendix I of CITES. The expected number of orders is the number of orders expected if each class was equally diverse in CITES.
<table>
<thead>
<tr>
<th></th>
<th>Appendix I</th>
<th>Appendix II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chi Squared Value</strong></td>
<td>48.56</td>
<td>34.16</td>
</tr>
<tr>
<td><strong>Degrees of Freedom</strong></td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>p&lt;0.0001</td>
<td>p&lt;0.001</td>
</tr>
</tbody>
</table>

*Table 21: Chi Square Goodness of Fit Test for the Number of Orders in the Classes of Chordata in Appendix I and Appendix II of CITES*

This table shows the results of the chi square goodness of fit test. As the table shows, the classes of Chordata were not equally diverse in Appendix I and Appendix II of CITES.
### The Observed and Expected Number of Species in the Orders of Mammalia in Appendix I of CITES for the Chi Square Goodness of Fit Test

<table>
<thead>
<tr>
<th>Order</th>
<th>Observed Number of Species</th>
<th>Expected Number of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artiodactyla</td>
<td>58</td>
<td>29.93</td>
</tr>
<tr>
<td>Carnivora</td>
<td>48</td>
<td>29.93</td>
</tr>
<tr>
<td>Cetacea</td>
<td>32</td>
<td>29.93</td>
</tr>
<tr>
<td>Chiroptera</td>
<td>11</td>
<td>29.93</td>
</tr>
<tr>
<td>Cingulata</td>
<td>1</td>
<td>29.93</td>
</tr>
<tr>
<td>Dasyuromorphia</td>
<td>2</td>
<td>29.93</td>
</tr>
<tr>
<td>Diprotodontia</td>
<td>8</td>
<td>29.93</td>
</tr>
<tr>
<td>Lagomorpha</td>
<td>2</td>
<td>29.93</td>
</tr>
<tr>
<td>Peramelemorphia</td>
<td>2</td>
<td>29.93</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td>22</td>
<td>29.93</td>
</tr>
<tr>
<td>Primates</td>
<td>220</td>
<td>29.93</td>
</tr>
<tr>
<td>Proboscidea</td>
<td>2</td>
<td>29.93</td>
</tr>
<tr>
<td>Rodentia</td>
<td>7</td>
<td>29.93</td>
</tr>
<tr>
<td>Sirenia</td>
<td>4</td>
<td>29.93</td>
</tr>
</tbody>
</table>

*Table 22: The Observed and Expected Number of Species in the Orders of Mammalia in Appendix I of CITES for the Chi Square Goodness of Fit Test*

This table shows the observed and expected number of species in the orders of Mammalia in Appendix I of CITES. The expected number of species is the number of species expected if each order was represented equally in CITES.
Chi Square Goodness of Fit Test for the Number of Species in the Orders of Mammalia in Appendix I, Appendix II, and Appendix III of CITES

<table>
<thead>
<tr>
<th></th>
<th>Appendix I</th>
<th>Appendix II</th>
<th>Appendix III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared Value</td>
<td>1446.88</td>
<td>2987.65</td>
<td>96.14</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>13</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>P-value</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
</tr>
</tbody>
</table>

*Table 23: Chi Square Goodness of Fit Test for the Number of Species in the Orders of Mammalia in Appendix I, Appendix II, and Appendix III of CITES*

This table shows the results of the chi square goodness of fit test. As the table shows, the orders of Mammalia were not represented equally in the three appendices of CITES.
<table>
<thead>
<tr>
<th>Order</th>
<th>Appendix I</th>
<th>Appendix II</th>
<th>Appendix III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Number of Species</td>
<td>Expected</td>
<td>Observed</td>
<td>Expected</td>
</tr>
<tr>
<td></td>
<td>Number</td>
<td>Number</td>
<td>Number</td>
</tr>
<tr>
<td>Artiodactyla</td>
<td>58</td>
<td>35.76</td>
<td>31</td>
</tr>
<tr>
<td>Carnivora, Chiroptera, Perissodactyla, and Pholidota</td>
<td>81</td>
<td>100.63</td>
<td>167</td>
</tr>
<tr>
<td>Cetacea</td>
<td>32</td>
<td>32.96</td>
<td>62</td>
</tr>
<tr>
<td>Cingulata, Pilosa, Proboscidea, and Sirenia</td>
<td>7</td>
<td>5.61</td>
<td>5</td>
</tr>
<tr>
<td>Dasyuromorphia, Diprotodontia, Monotremata, and Peramelemorphia</td>
<td>12</td>
<td>8.06</td>
<td>11</td>
</tr>
<tr>
<td>Lagomorpha, Rodentia, and Scandentia</td>
<td>9</td>
<td>14.03</td>
<td>24</td>
</tr>
<tr>
<td>Primates</td>
<td>220</td>
<td>221.95</td>
<td>413</td>
</tr>
</tbody>
</table>

Table 24: The Observed and Expected Number of Species in the Orders of Mammalia in Appendix I, Appendix II, and Appendix III of CITES for the Chi Square Homogeneity of Proportions Test

This table shows the observed and expected number of species in the orders of Mammalia in the three appendices of CITES. The expected number of species is the number of species expected if the number of species in each order within an appendix was proportional to the total number of species in each order in all of CITES and the total number of species protected within that appendix.
This table shows the results of the chi square homogeneity of proportions test. As the table shows, the number of species in the orders of Mammalia did not deviate significantly from the expected numbers of species in Appendix I and Appendix II.
## The Observed and Expected Number of Species in the Phyla of Animalia in Appendix II of CITES for the Chi Square Goodness of Fit Test

<table>
<thead>
<tr>
<th>Phylum</th>
<th>Observed Number of Species</th>
<th>Expected Number of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annelida</td>
<td>2</td>
<td>1062.40</td>
</tr>
<tr>
<td>Arthropoda</td>
<td>81</td>
<td>1062.40</td>
</tr>
<tr>
<td>Chordata</td>
<td>3109</td>
<td>1062.40</td>
</tr>
<tr>
<td>Cnidaria</td>
<td>2104</td>
<td>1062.40</td>
</tr>
<tr>
<td>Mollusca</td>
<td>16</td>
<td>1062.40</td>
</tr>
</tbody>
</table>

*Table 26: The Observed and Expected Number of Species in the Phyla of Animalia in Appendix II of CITES for the Chi Square Goodness of Fit Test*

This table shows the observed and expected numbers of species in the phyla of Animalia in Appendix II of CITES. The expected number of species is the number of species expected if each phylum was represented equally in Appendix II.
### Table 27: The Observed and Expected Number of Orders in the Phyla of Animalia in Appendix II of CITES for the Chi Square Goodness of Fit Test

This table shows the observed and expected numbers of orders in the phyla of Animalia in Appendix II of CITES. The expected number of orders is the number of orders expected if each phylum was equally diverse in Appendix II.

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Appendix II</th>
<th>Expected Number of Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed Number of Orders</td>
<td></td>
</tr>
<tr>
<td>Annelida</td>
<td>1</td>
<td>12.4</td>
</tr>
<tr>
<td>Arthropoda</td>
<td>4</td>
<td>12.4</td>
</tr>
<tr>
<td>Chordata</td>
<td>46</td>
<td>12.4</td>
</tr>
<tr>
<td>Cnidaria</td>
<td>6</td>
<td>12.4</td>
</tr>
<tr>
<td>Mollusca</td>
<td>5</td>
<td>12.4</td>
</tr>
</tbody>
</table>
## The Observed and Expected Number of Species in the Classes of Chordata in Appendix II of CITES for the Chi Square Goodness of Fit Test

<table>
<thead>
<tr>
<th>Class</th>
<th>Observed Number of Species</th>
<th>Expected Number of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actinopterygii</td>
<td>83</td>
<td>444.14</td>
</tr>
<tr>
<td>Amphibia</td>
<td>142</td>
<td>444.14</td>
</tr>
<tr>
<td>Aves</td>
<td>1444</td>
<td>444.14</td>
</tr>
<tr>
<td>Elasmobranchii</td>
<td>10</td>
<td>444.14</td>
</tr>
<tr>
<td>Mammalia</td>
<td>713</td>
<td>444.14</td>
</tr>
<tr>
<td>Reptilia</td>
<td>716</td>
<td>444.14</td>
</tr>
<tr>
<td>Sarcopterygii</td>
<td>1</td>
<td>444.14</td>
</tr>
</tbody>
</table>

*Table 28: The Observed and Expected Number of Species in the Classes of Chordata in Appendix II of CITES for the Chi Square Goodness of Fit Test*

This table shows the observed and expected numbers of species in the classes of Chordata in Appendix II of CITES. The expected number of species is the number of species expected if each class was represented equally in CITES.
Table 29: The Observed and Expected Number of Orders in the Classes of Chordata in Appendix II of CITES for the Chi Square Goodness of Fit Test

This table shows the observed and expected number of orders in the classes of Chordata in Appendix II of CITES. The expected number of orders is the number of orders expected if each class was equally diverse in CITES.
<table>
<thead>
<tr>
<th>Order</th>
<th>Observed Number of Species</th>
<th>Expected Number of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artiodactyla</td>
<td>31</td>
<td>50.93</td>
</tr>
<tr>
<td>Carnivora</td>
<td>95</td>
<td>50.93</td>
</tr>
<tr>
<td>Cetacea</td>
<td>62</td>
<td>50.93</td>
</tr>
<tr>
<td>Chiroptera</td>
<td>59</td>
<td>50.93</td>
</tr>
<tr>
<td>Cingulata</td>
<td>1</td>
<td>50.93</td>
</tr>
<tr>
<td>Diprotodontia</td>
<td>8</td>
<td>50.93</td>
</tr>
<tr>
<td>Monotremata</td>
<td>3</td>
<td>50.93</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td>5</td>
<td>50.93</td>
</tr>
<tr>
<td>Pholidota</td>
<td>8</td>
<td>50.93</td>
</tr>
<tr>
<td>Pilosa</td>
<td>3</td>
<td>50.93</td>
</tr>
<tr>
<td>Primates</td>
<td>413</td>
<td>50.93</td>
</tr>
<tr>
<td>Proboscidea</td>
<td>1</td>
<td>50.93</td>
</tr>
<tr>
<td>Rodentia</td>
<td>4</td>
<td>50.93</td>
</tr>
<tr>
<td>Scandentia</td>
<td>20</td>
<td>50.93</td>
</tr>
</tbody>
</table>

Table 30: The Observed and Expected Number of Species in the Orders in Mammalia in Appendix II of CITES for the Chi Square Goodness of Fit Test

This table shows the observed and expected numbers of species in the orders of Mammalia in Appendix II of CITES. The expected number of species is the number of species expected if each order was represented equally in CITES.
The Observed and Expected Number of Species in the Phyla of Animalia Appendix III of CITES for the Chi Square Goodness of Fit Test

<table>
<thead>
<tr>
<th>Phylum</th>
<th>Observed Number of Species</th>
<th>Expected Number of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthropoda</td>
<td>20</td>
<td>39.75</td>
</tr>
<tr>
<td>Chordata</td>
<td>134</td>
<td>39.75</td>
</tr>
<tr>
<td>Cnidaria</td>
<td>4</td>
<td>39.75</td>
</tr>
<tr>
<td>Mollusca</td>
<td>1</td>
<td>39.75</td>
</tr>
</tbody>
</table>

*Table 31: The Observed and Expected Number of Species in the Phyla of Animalia Appendix III of CITES for the Chi Square Goodness of Fit Test*

This table shows the observed and expected number of species in the phyla of Animalia in Appendix III of CITES. The expected number of species is the number of species expected if each phylum was represented equally in Appendix III.
The Observed and Expected Number of Orders in the Phyla of Animalia in Appendix III of CITES for the Chi Square Goodness of Fit Test

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Observed Number of Orders</th>
<th>Expected Number of Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthropoda</td>
<td>2</td>
<td>5.5</td>
</tr>
<tr>
<td>Chordata</td>
<td>18</td>
<td>5.5</td>
</tr>
<tr>
<td>Cnidaria</td>
<td>1</td>
<td>5.5</td>
</tr>
<tr>
<td>Echinodermata</td>
<td>1</td>
<td>5.5</td>
</tr>
</tbody>
</table>

*Table 32: The Observed and Expected Number of Orders in the Phyla of Animalia in Appendix III of CITES for the Chi Square Goodness of Fit Test*

This table shows the observed and expected number of orders in the phyla of Animalia in Appendix III of CITES. The expected number of orders is the number of orders expected if each phylum was equally diverse in Appendix III.
The Observed and Expected Number of Species in the Classes of Chordata in Appendix III of CITES for the Chi Square Goodness of Fit Test

<table>
<thead>
<tr>
<th>Class</th>
<th>Observed Number of Species</th>
<th>Expected Number of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibia</td>
<td>3</td>
<td>33.50</td>
</tr>
<tr>
<td>Aves</td>
<td>28</td>
<td>33.50</td>
</tr>
<tr>
<td>Mammalia</td>
<td>63</td>
<td>33.50</td>
</tr>
<tr>
<td>Reptilia</td>
<td>40</td>
<td>33.50</td>
</tr>
</tbody>
</table>

Table 33: The Observed and Expected Number of Species in the Classes of Chordata in Appendix III of CITES for the Chi Square Goodness of Fit Test

This table shows the observed and expected number of species in the classes of Chordata in Appendix III of CITES. The expected number of species is the number of species expected if each class was represented equally in Appendix III.
Appendix B: Bibliography for CITES Contents

Below are the resources used to ascertain the correct number of species and subspecies listed in CITES. The Excel documents listing the number of species and subspecies used to assess the validity of the hypothesis can be accessed by contacting the author: Laura Jenkins at lejenk01@syr.edu. This email should be active at least until May 2018.


(2013). *Consideration of Proposals for Amendment of Appendices I and II*. Bangkok: CITES.


