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A Review of Mammalian Ectoparasites from the Northern Chihuahuan Desert

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Abstract–Ectoparasites tend to be an underappreciated facet of mammalian natural history. This is in light of their possible involvement with changes in roosting and nesting behavior, daily activity patterns, transmission of pathogens and the growth and development of mammals. In order to better appreciate the diversity of ectoparasitic organisms present in the Chihuahuan Desert region, a compilation of known ectoparasite-host relationships has been gathered for the diverse mammalian species known to occur within the northern extent of the desert's boundaries. Ectoparasites reported include fleas (Siphonaptera), lice (Phthiraptera), true bugs (Hemiptera), flies (Diptera), ticks (Ixodida), and other mites (Acari). Common methods for the collection and recovery of ectoparasitic insects and acari from mammals are presented. The variety of parasitic forms found is discussed, combined with aspects of natural history, such as methods of feeding, host attachment, and known pathogen vectoring. In addition, a few areas of future study are suggested, including the need to collect, identify, describe, and begin the ecological study on several largely overlooked groups of ectoparasites.

In keeping with the theme of documenting the unique biodiversity associated with the Chihuahuan Desert at this symposium, I present a summary of the ectoparasites known to be associated with mammals in the northern extent of the Chihuahuan Desert, ranging south to the Rio Grande. This report, while not complete, as no such work of this nature is ever truly complete, encompasses the majority of the different ectoparasitic groups, from insects to Acari. It should be noted that several groups are being excluded from this report, as a factor of their unique status. Those parasites that border on the definition of endoparasite and ectoparasite, such as those found within internal organs, respiratory passages, or those that burrow into the skin, are not covered. They include the mite families Demodicidae, Sarcoptidae, and Psoroptidae, although chiggers (Families Leeuwenhoekiidae and Trombiculidae) are included due to their general external attachment. Additionally, although botflies (Family Cuterebridae) are tissue or sub-dermal parasites, their inclusion in this review seeks future researchers to include these occurrences in parasitic surveys. All told, a total of four orders of Insecta and four orders of Acari are included in the present review.

Although some information was found pertaining to ectoparasites of mammals in the Chihuahuan Desert, much remains to be discovered in terms of parasite-host associations, ecology, and basic natural history. Other regions of North America, such as the Midwest (Mumford and Whitaker 1982) and the Pacific Coast (Maser 1998), have underlined the importance and influence of ectoparasites on their vertebrate hosts. Parasites have been found to affect hosts in a number of different ways, including daily activity patterns, den selection and fidelity, growth and development, and reproduction and fitness. The effect of ectoparasites on daily activity patterns has been shown to decrease the amount of undisturbed rest a host receives. With increased ectoparasite load, hosts will spend more time grooming to try to alleviate the irritation caused by the parasites, and less time sleeping (Giorgi et al. 2001). This can result in an overall decrease in body mass and the general health of an individual. Because many ectoparasites are facultative parasites, only occurring on the host to feed, the selection of den or nest site can greatly influence parasite abundance. In fact, a study in the western United States showed that a small number of fleas on a host may indicate up to one hundred in the nesting material (Whitaker 1968). Such data suggests that hosts may abandon or switch nests to escape the pressures of parasitism (Christe et al. 1994). This is just one of the current theories behind low roost fidelity in bats (Lewis 1995, 1996). A fundamental reason behind careful nest selection ties back to the impact parasites can have on developing young. Several studies (Brown and Brown 1986; Richner et al. 1993; Szep and Moller 2000) have shown that increased numbers of ectoparasites can have a detrimental effect on the growth and development of young hosts. Since juveniles are typically incapable of performing efficient grooming techniques to reduce the effects of ectoparasites, they are a natural target for many different groups of ectoparasites. Under conditions of high parasite load and reduced parental care, young grow more slowly and fledge at smaller sizes than those without such parasitic pressures (Brown and Brown 1986; Ritzi 2004). This can be critically important in the understanding and management of different host species.

Finally, parasites can dramatically affect mate selection, reproduction, and ultimate fitness. Numerous studies have documented how the external appearance of hosts can be used in selecting mates, and how those individuals that are parasitized may be displayed as less favorable to potential mates (Moller 1993; Kose et al. 1999; Griffith 2000; Roulin et al. 2001; Moore and Wilson 2002). Thus, parasites not only affect the general health of an organism in this life, but have the potential to influence the evolutionary pattern of a species over time.

Chihuahuan Desert Region–The Chihuahuan Desert region, as outlined by Schmidly (1977a), is contained within the 99th and 108th meridians and the 21st and 33rd parallels. It covers the southern extents of New Mexico, the Trans-Pecos region of Texas in the United States of America, as well as parts of the Mexican states of Chihuahua, Coahuila, Durango, Zacatecas, Nuevo Leon, San Luis Potosi, Aguascalientes, and Tamaulipas. For the purposes of this review, only the northern range of the Chihuahuan Desert is under consideration. This region is denoted as the southern parts of New Mexico, the Trans-Pecos region of Texas, and the Mexican State of Chihuahua. Within this region, approximately 100 species of mammals are believed to occur (Schmidly 1977b, 2004). These mammals belong to the following Orders in descending species diversities in the region: Rodentia, Chiroptera, Artiodactyla, Carnivora, Lagomorpha, Insectivora, Xenarthra, and Didelphimorphia. Of these mammal species, only about 50% have been sampled for a single parasite species. Within these representatives, only two groups, Order Chiroptera and Order Rodentia, Family Heteromyidae, have been sampled with any intensity for ectoparasites. As such, much remains to be learned about the ectoparasites that occur on the mammals of the northern Chihuahuan Desert.

Methods and Materials–Recovering ectoparasites from mammals ideally involves the direct observation of skins and carcasses under magnification while parting the hairs with pins or dissecting probes. This technique (Whitaker et al. 1993; Ritzi 2004) has been found to recover the largest abundance and diversity of ectoparasites from a host, particularly the tiny mites that dwell on the hair shafts. It is also useful for ecological data, such as site specificity, and provides information about host-parasite interactions. It is important to record information including types and numbers of parasites recovered per area of the host, so that these data can later be used after specimen identification has been conducted to learn more about the natural history of these parasites.

Another technique useful for the recovery of ectoparasites from carcasses or skins is the washing technique (Whitaker et al. 1993; Ritzi and Whitaker 2003), which involves agitating the specimen in soapy water, and filtering the liquid. Specifically, the skin is placed within a container large enough to hold the carcass and water. Once in the container, the specimen is covered with water and a small amount of detergent (0.1 grams or a pinch). The container is sealed and vigorously shaken for at least one minute, to dislodge parasites hidden or clinging to fur. The carcass is removed from the wash, rinsed with ethanol (to reduce soap suds) over the container, and placed on a

towel to dry before further mammal preparation. The wash can then be run through a filtering flask and Buchner funnel with filter paper under vacuum. Recovered parasites will be stuck on the filter paper in the funnel, which can be placed in a covered Petri dish until microscopic examination. This technique is efficient for recovering a large number of the ectoparasites that cling to the fur, but is insufficient for extracting parasites that burrow or anchor onto the skin, such as stick-tight fleas, chiggers, and ticks (Ritzi and Sparks 2002). For this reason, it is still wise to visually examine the skin under a microscope for attached parasites after washing.

Some techniques can be used on live, or restrained, animals. The two techniques that have received some attention are the brushing technique and visual examination. The brushing technique involves holding the specimen over a flat surface, typically a white enamel tray, and brushing the fur with a brush of medium stiffness, such as a toothbrush or flea comb. This process dislodges parasites in the fur, and then visual examination around the ears, eyes, and mouth of the animal can add to the parasites recovered. Any parasites dislodged in this manner can be collected from the tray and stored in 70% ethanol until slide mounting and identification.

The final technique is a modification of the dissecting microscope technique outlined above, using a limited form of magnification on living hosts. In this technique, modified for bats by Ritzi et al. (2001), the host is restrained against a flat contrasting colored surface, and visually scanned for ectoparasites on all body surfaces while wearing magnification in the form of jeweler's glasses (10X) or a magnifying head shield. The fur should still be parted using either dissecting probes or fine forceps, with the recovery of any potential ectoparasites from the fur. As with the dissecting scope technique, efforts should be made to denote site specificity of ectoparasites, as well as differences between various life stages of parasitic groups. Parasites recovered in this way can also be stored in vials of 70% ethanol until mounting and identification can take place in a laboratory.

Although other techniques have been discussed in the literature for the recovery of ectoparasites, the above four techniques tend to provide the most efficient results. The preferred technique is the dissecting microscope technique, followed by the washing technique, when one is processing carcasses or skins. In the case of live animals, the modified dissecting technique outlined above is preferred, with the brushing technique to be used only when other options are unavailable. These techniques provide varying degrees of information about ectoparasites and their hosts, and typically recover ectoparasites in good condition for preservation and identification.

Once parasites have been collected from a host, they should be preserved and identified directly in ethanol, as in the case of most tick, fly, and hemiperan species, or be slide mounted for more detailed observation. A summary of different slide mounting mediums and techniques is outlined by Krantz (1986), with Hoyer's medium being the most preferred medium by acarologists and parasitologists in North America for mites and small insects, and Canada balsam for fleas and other larger mounts. A substitute for this in more tropical regions is a poly-vinyl alcohol mounting medium containing lactophenol for clearing, although this does not allow later manipulation of the specimen if further dissection and remounting is required. I suggest that individuals collecting ectoparasites should learn to master the technique of slide mounting, in that this readily speeds up the process of parasite identification. Slide mounting is encouraged by specialists if specimens need to be sent for identification or verification.

Results and Discussion—Known mammalian ectoparasites of the northern Chihuahuan Desert have been found to belong to four orders of Insecta and four potential orders of Acari (as proposed by Evans 1992). This represents 192 species documented in the region: 48 fleas, 10 flies, 20 lice, 3 true bugs, 21 ticks, 56 mites excluding chiggers, and 34 chiggers (Appendix 1). Each of these groups is discussed below.

Parasitic insects from the northern Chihuahuan Desert consist of four orders: Diptera (the true flies), Hemiptera (the true bugs), Phthiraptera (the sucking and chewing lice), and Siphonaptera (the fleas). These organisms possess three pairs of legs, one set of antennae, and most lack wings. The reason for this reduction or loss of wings (as well as some other structures) in many of the ectoparasitic insects has been discussed in detail elsewhere (Marshall 1981).

Diptera—True flies are characterized by having a single pair of functional wings and a reduced second pair of wings formed into halteres, used in maintaining a stable equilibrium. Although there is a broad diversity of families within this family, only three families are known to parasitize mammals in the southern United States and México.

Cuterebridae—The New World botflies. The larval stages of members of this family develop just under the skin on the host, typically with a portion of their body exposed on the surface (Triplehorn and Johnson 2005). Final-instar larvae tend to be fairly large, around 25 to 30 mm in length, and can occur in large numbers around the head and rump of a host. Although the normal hosts for these fly larvae are murid rodents and lagomorphs, many other species can serve as hosts for botflies, including humans. Currently, only one record of *Cuterebra* was associated with the Chihuahuan

Desert, although there have been numerous observations made by myself and others that will expand the list of parasitized hosts for the region in the future.

Nycteribiidae—These wingless batflies have evolved to superficially resemble spiders. They possess long legs modified to grasp hairs, a hinged head that is typically reflexed on the back or the thorax except during feeding, and wings that are absent. These flies do not lay eggs like most, but deposit puparia in the roost, that hatch as adults. All of these wingless batflies are collected from bats, typically in the tropical regions of the world. Only one genus, *Basilia*, is known to occur on bats in the Chihuahuan Desert.

Streblidae—Winged bat flies are also modified for a parasitic existence, but they still maintain their wings and are proficient fliers. When they are moving about their hosts, they keep their wings folded across their abdomens to minimize the difficulty in navigating fur. They also tend to have modified legs for grasping hairs, and deposit puparia. Most of the species are dorsal-ventrally flattened in part, but members of one genus (*Nycterophilia*) are laterally flattened and resemble fleas in their body shape and movement patterns. Two genera of this family are known to occur in this region.

Hemiptera—The true bugs are identified by possessing piercing mouthparts (a proboscis), for sucking fluids from their prey, and by their characteristic wing morphology. Unfortunately, the parasitic families of Hemiptera are lacking these wings (with the exception of the tiratomids), and therefore are recognized by their mouthparts and typically dorsal-ventrally flattened bodies. Both families of parasitic true bugs, Cimicidae and Polyctenidae, are known parasites of bats from the Chihuahuan Desert.

Cimicidae—This group consists of bedbugs and swallow bugs. All of these insects feed by piercing their host with a proboscis and then sucking blood. They are typically broad-bodied and flat, averaging around 5 mm in length. Most cimicids are obligate hematophages, moving onto the hosts in the nest or roost to feed, and hiding in cracks and crevices when they are not. This group has been studied in detail by Usinger (1966), who reported on their taxonomy and biology. Only two species, each belonging to separate genera, were documented on wild bats in the region, with the record for *Oeciacus* resulting from bats roosting in swallow nests (Ritzi et al. 2001). As the common bedbug, *Cimex lectularis*, occurs on humans worldwide, its presence on the indigenous people of the area is also anticipated in the medical literature (Usinger 1966).

Polyctenidae—The polyctenids are a rare group of hemipterans isolated on bats in the New and Old World tropical and subtropical regions. They possess many similarities

to the nycteribiid bat flies, in that the first specimen described was actually placed within that dipteran family (Ferris and Usinger 1939). These bat bugs average about 3 to 5 mm in length, and are distinguished from the cimicids by having a longer, thinner body. They also differ from cimicids in that they are obligate parasites, spending their entire life on the host. They give birth to live young, lack eyes, and have modified limbs for clinging to bats. Of the 32 species known to exist in this family, only one species is known to occur in México.

Phthiraptera—The sucking and chewing lice have traditionally been recognized as two separate orders, Anoplura and Mallophaga. These groups have been distinguished by their feeding strategies, in that Anoplura use a piercing set of stylets to suck blood from mammalian hosts, while the Mallophaga use mandibulate plates to grind up the hair, skin, or feathers of hosts. While the Anoplura have been maintained as a single suborder, Mallophaga has been divided into three suborders, consisting of Amblycera, Ischnocera, and Rhyncophthirina (Triplehorn and Johnson 2005). The latter two suborders, and a portion of the first, are known to parasitize mammals. The majority of Amblycera; however, typically are avian parasites.

Anoplura—This group of lice is commonly known as the sucking lice, and all are parasitic upon mammals. A total of 17 different species of sucking lice have been reported from the northern Chihuahuan Desert, primarily from rodent species.

Ischnocera—The mallophagans within this suborder are divided into three genera within the region, one for each of the primary lineages of mammalian chewing lice. Separate lineages of chewing lice have been found on artiodactyls, carnivores, and geomyid rodents. Although more than three genera are known to occur in other regions of North America (Price et al. 2003), the single records from each of the different groups of hosts is an encouraging start for this work. In particular, a great deal of taxonomic work has been conducted on the pocket gophers and their chewing lice in North and South America, resulting in the current recognition of over 122 species and subspecies of lice in México alone. Further work in the Chihuahuan Desert will help to add to this pool of knowledge.

Siphonaptera—Fleas are a specialized group of parasitic insects that are bi-laterally flattened, lack wings, and have hind legs modified for jumping. Although only adults are typically parasitic, larvae commonly feed on organic material including (for some species) adult flea feces rich in undigested host blood. The body shape of fleas helps them to maneuver through the host's fur, while modified setae form combs or ctenidia, which reduce dislodgement due to host grooming. Fleas are closely monitored due to their role as potential pathogen vectors, particularly for plague (Holdenried and

Morlan 1955). Currently, six families of fleas are reported from the region, with most of them parasitizing rodents, lagomorphs, and carnivores. Ischnopsyllidae; however, are restricted solely to bat hosts.

The Acari include mites and ticks, that are united by possessing four pairs of legs during their adult lives and lacking antennae. Larval Acari differ from adults in that they have three pairs of legs, and can be mistaken for insects at first glance. The orders of Acari presented herein are those proposed by Evans (1992), although the current higher taxonomy of Acari is highly debated.

Ixodida—The ticks are actually a group of enlarged mites that are distinguished from other mites by the possession of a toothed hypostome. This structure is used to pierce and anchor the tick to its host while it feeds to engorgement. They also possess a sensory Haller's organ on the tarsus of the first leg. Due to their large size, records of ticks are abundant, with representatives of two families of ticks collected in the northern Chihuahuan Desert.

Argasidae—Soft ticks, as members of this family are commonly known, are typically parasites of birds, rodents, and flying mammals. They are called soft ticks due to their lack of a dorsal scutum or shield, giving them a fleshy appearance. Sexes of this family are also similar in appearance, making initial determinations difficult without microscopy. Larval forms of these ticks normally attach to their host for several days, and are the most common life stage associated with mammals in the literature. Most records of the two genera reported from the Chihuahuan Desert are reported from bats, although several records exist for rodent and lagomorph hosts as well.

Ixodidae—Hard ticks possess a hard scutum or shield on their dorsal surface. Females, which have to engorge on blood prior to egg laying, have a scutum that covers the anterior part of their dorsal surface, while males have their entire dorsal surface protected. Adult ticks are readily collected because of their large size and because they remain on the host for days to occasionally weeks of time. Another reason for their dominance in the literature is their potential as pathogen vectors, being responsible for transmitting several pathogens including those that cause Rocky Mountain spotted fever, Lyme disease, and Texas cattle fever. A total of 12 species of hard ticks from five different genera have been documented in the northern Chihuahuan Desert.

Mesostigmata—These medium-sized mites include several families of facultative ectoparasites of mammals and birds. They range in size from 200 to 2000 μm, and possess several characteristics that unite them as a group. All Mesostigmata possess a pair of stigmatic (respiratory) openings around the 2nd or 3rd pair of legs, typically on a shield called the peritreme. They have an undivided triosternum, and a transverse genital

opening in the intercoxal region of females for production of young (Krantz 1986). Representatives of only three families of Mesostigmata have been documented from the northern Chihuahuan Desert, but seven different families have been documented in other parts of Mexico (Whitaker and Morales-Malacara in press).

Laelapidae—Laelapid mites are one of the most abundant and diverse group of parasitic mites on mammals around the world (Tipton 1960). Some of them tend to be relatively host specific, occurring on only one or two host species, while others, such as *Androlaelaps fahrenholzi*, have been collected from over 100 species of North American mammals (Whitaker and Morales-Malacara in press). A total of six genera of Laelapidae have been documented from the region.

Macronyssidae—Macronyssids are a group of mesostigmatid mites similar in size and morphology to Laelapidae. The main morphological difference between these two groups is the shape of their epigential shields, in that macronyssids have elongate shields while laelapids have tear-drop shaped shields. Many in this family are known to parasitize bats, although members of the genus *Ornithonyssus* are commonly bird parasites. Some macronyssids also readily transfer to other groups as well, as shown by records reported from heteromyid rodents in the region.

Spinturnicidae—These large, round mites (typically greater than 2 mm) are parasitic solely on bats. They are normally found on the wing membranes, where their thick circularly dispersed legs allow them to cling to the wing membrane, even during flight. Several records exist from throughout the United States and México, with two genera found in the northern Chihuahuan Desert.

Prostigmata—The Prostigmata are united by stigmata located at or near the gnathosoma, possession of a podocephalic canal, and a pair of specialized sensory sensilla called trichobothria (Krantz 1986). Of the five families of Prostigmata reported from México, only three of these families are currently documented within the region of this study.

Leeuwenhoekiidae—Revisions in the Trombidiina have resulted in the larval mites known as "chiggers" to now belong to three families, Leeuwenhoekiidae, Walchiidae, and Trombiculidae (Wen 1999). Members of the family Leeuwenhoekiidae are distinguished primarily by having two anterior medial setae and a naso (projection) on the scutal shield, as well as two setae on the first coxal field and four setae on each genu of legs II and III. Other than these morphological characters, members of this family appear and behave as normal chigger mites, parasitizing hosts during their larval

stage, and then dropping to the ground to molt into predatory nymphal and final adult forms. In the northern Chihuahuan Desert, only four genera are currently recorded for this family.

Myobiidae—Myobiid mites represent the only family of prostigmatid mite reported in this review that are obligate parasites of mammals, being found on the host during all life stages. These mites have highly modified legs I for clinging to hairs, and have become highly host specific over time. As such, there are a large number of myobiid mites known from the United States alone, numbering 12 different genera (Whitaker and Wilson 1974; Whitaker et al. 2007). When compared to the four genera reported from the Chihuahuan Desert region, the need to more closely examine hosts for these parasites becomes apparent.

Trombiculidae—The traditional family of the chigger mites, this speciose group contains the majority of the chigger mite species known in both North America and México. These mites tend to show a low level of host specificity, instead being habitat specific. These chiggers are not particular about which mammalian host they feed from, as long as that host moves through the specific habitat that the chigger is developing within. This group of parasites has also been linked to pathogen transmission, being responsible for the spread of scrub typhus in the Asian tropics. Although they have not been proven to transmit any disease-causing pathogens in the Chihuahuan Desert, continued study and observation of this group may aid in our understanding of pathogen transmission. Due to their importance in medical and veterinary science, a total of 14 genera have been documented within the region.

Astigmata—The Astigmata are small mites characterized by having the coxae of their legs fused to the venter forming distinctive coxal fields, a gap (diastima) between legs II and III, and lacking stigmatic openings (Krantz 1986). These mites, often between 100 to 500 μm in length, are often associated with either the fur or the skin follicles of mammalian hosts when parasitic. Of seven families reported from México (Whitaker and Morales-Malacara in press), only three families are reported within this work. If one were to extend the definition of ectoparasite to those mites that burrow into the skin or invade respiratory passages, the number of families potentially could be increased by at least two families.

Glycyphagidae—These mites are commonly collected from the fur of mammals while they are dispersing in their deutonymph stage. During this time, these mites do not feed, i.e. they are phoretic rather than parasitic, and use the host as a means to move

from one place to another. Although ten genera are reported from North America (Whitaker and Wilson 1974; Whitaker et al. 2007), only two genera have currently been documented in the region.

Listrophoridae—Members of this group of tiny fur mites are commonly found crawling up and down individual shafts of hair on their hosts. Their small size (300 to 500 μm in length) has resulted in this group being largely overlooked by most workers, although high levels of infestation have been reported (Fain and Whitaker 1987). Also, due to their limited dispersal ability and dependence on their hosts, these mites tend to be highly host specific, with different species found at the generic and species level of host infestation. Of the ten known genera of Listrophoridae in North America (Whitaker and Wilson 1974; Whitaker et al. 2007), only two genera have been recorded from within the northern Chihuahuan Desert region.

Rosensteiniidae—This odd group of mites consists of eight known species, one associated with cockroaches and the remaining seven associated with bats (O'Connor and Reisen 1978). Of those mites found with bats, most live within the guano community, although they are occasionally found on bats. Their connection with bats appears to be phoretic, in that neither blood nor tissue fluid has been found within the guts of the hitch-hiking Acari.

Future Works—A brief examination of the records contained within this work would cause one to think that there is an abundance of information currently available about ectoparasites. However, a closer examination, particularly when compared to other regions of North America and México, indicate that the northern Chihuahuan Desert is woefully delinquent in its documentation of mammalian ectoparasites. We have just scratched the surface of the known ectoparasites in this region. In particular, several families of Acari, including Atopomelidae, Chirodiscoidae, Demodicidae, and Sarcoptidae, are not represented in this review, and their collection and addition will aid in expanding the biodiversity associated with the Chihuahuan Desert. It is also important that roughly half of the mammalian host species in the region have never been sampled. How many more species of Listrophoridae, Myobiidae, or Phthiraptera might be recovered and added to the taxa found within this part of the world with additional host sampling? For example, the first beaver or nutria examined for ectoparasites within the area will likely produce up to 15 new ectoparasite records for the northern Chihuahuan Desert. Toward this end, efforts should be made to conduct sampling surveys of the mammals in the region for ectoparasites. Although live sampling and visual observations of parasites are helpful, the careful examination

of mammals to be vouchered using magnification will yield the greatest amount of information about the ectoparasitic fauna.

It is almost inevitable that species new to science will be discovered in the course of these surveys. This will not only increase the number of species associated with the region, but will add to the number of endemic organisms found in this part of the desert. The characteristic fauna of the Chihuahuan Desert helps to delineate the biotic region, and recognition of new species can only add to the uniqueness of this area. Only after this inventory has taken place can researchers begin to study the natural history, ecology, and host-parasite interactions of the desert fauna. An expansion of the ectoparasitic inventory for this region is a necessary first step in better understanding the biodiversity that occurs within the northern Chihuahuan Desert region.

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APPENDIX 1–Summary of the ectoparasites of mammals from the northern Chihuahuan Desert. Host names are followed by literature citations corresponding to the specific records for each parasite species.

Ectoparasite	Host	Citation
DIPTERA		
Streblidae		
Nycterophilia mormoopsis	*Mormoops megalophylla*	Whitaker & Easterla 1975
Trichobius corynorhini	*Antrozous pallidus*	Ritzi et al. 2001
	Corynorhinus townsendii	Ritzi et al. 2001; Wenzel 1970; Whitaker & Easterla 1975
	Myotis volans	Whitaker & Easterla 1975
Trichobius leionotus	*Mormoops megalophylla*	Whitaker & Easterla 1975
Trichobius major	*Myotis velifer*	Ritzi et al. 2001; Whitaker & Easterla 1975
Trichobius sphaeronotus	*Leptonycteris nivalis*	Wenzel 1970; Whitaker & Easterla 1975
Nycteribiidae		
Basilia antrozoi	*Antrozous pallidus*	Richerson et al. 1992; Ritzi et al. 2001; Whitaker & Easterla 1975
	Lasiurus cinereus	Whitaker & Easterla 1975
Basilia corynorhini	*Corynorhinus townsendii*	Whitaker & Easterla 1975
	Leptonycteris nivalis	Whitaker & Easterla 1975
Basilia forcipata	*Eptesicus fuscus*	Whitaker & Easterla 1975
	Myotis velifer	Ritzi et al. 2001
	Myotis volans	Whitaker & Easterla 1975
	Myotis thysanodes	Whitaker & Easterla 1975
Basilia rondanii	*Antrozous pallidus*	Whitaker & Easterla 1975
	Euderma maculatum	Whitaker & Easterla 1975
	Pipistrellus hesperus	Whitaker & Easterla 1975
	Myotis volans	Whitaker & Easterla 1975
	Myotis yumanensis	Ritzi et al. 2001; Whitaker & Easterla 1975
Cuterebridae		
Cuterebra sp.	*Peromyscus nasutus*	Whitaker 1968

APPENDIX 1–*continued*

Ectoparasite	Host	Citation
HEMIPTERA		
Cimicidae		
Cimex pilosellus	*Antrozous pallidus*	Dooley et al. 1976
	Myotis velifer	Ritzi et al. 2001
	Pipistrellus hesperus	Dooley et al. 1976; Whitaker & Easterla 1975
Oeciacus vicarius	*Myotis velifer*	Ritzi et al. 2001
Polyctenidae		
Hesperoctenes eumops	*Eumops perotis*	Whitaker & Easterla 1975
PHTHIRAPTERA		
Hoplopleuridae		
Hoplopleura acanthopus	*Microtus mexicanus*	Timm 1985
Hoplopleura ferrisi	*Peromyscus boylei*	Whitaker 1968
	Peromycus nasutus	Whitaker 1968
Hoplopleura hesperomydis	*Onchomys leucogaster*	Morland & Hoff 1957
	Peromyscus leucopus	Whitaker 1968
	Peromyscus truei	Whitaker 1968
Hoplopleura hirsuta	*Onychomys arenicola*	Macaluso 1996
	Sigmodon hispidus	Richerson et al. 1992
Hoplopleura pacificus	*Rattus rattus*	Pratt & Good 1954
Pecaroecidae		
Pecaroecus javalii	*Pecari tajacu*	Richerson et al. 1992
Polyplacidae		
Fahrenholzia boleni	*Perognathus flavus*	Whitaker et al. 1993
Fahrenholzia ehrlichi	*Liomys irroratus*	Whitaker et al. 1993
Fahrenholzia pinnata	*Chaetodipus penicillatus*	Morlan & Hoff 1957; Whitaker et al. 1993
	Dipodomys merriami	Morlan & Hoff 1957; Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993

APPENDIX 1—*continued*

Ectoparasite	Host	Citation
Fahrenholzia texana	*Liomys irroratus*	Whitaker et al. 1993
Linognathoides laeviusculus	*Spermophilus variegatus*	Ritzi & Sparks 2002
Neoheamatopinus citellinus	*Spermophilus tereticaudus*	Morlan & Hoff 1957
Neoheamatopinus neotomae	*Dipodomys ordii*	Whitaker et al. 1993
	Neotoma micropus	Richerson et al. 1992
Polyplax alaskensis	*Microtus mexicanus*	Timm 1985
Polyplax auricularis	*Onchomys leucogaster*	Morlan & Hoff 1957
	Peromyscus maniculatus	Whitaker 1968
	Peromyscus nasutus	Whitaker 1968
	Peromyscus truei	Whitaker 1968
Polyplax spinulosa	*Rattus rattus*	Pratt & Good 1954
Enderleinellidae		
Enderleinellus suturalis	*Spermophilus spilosoma*	Morlan & Hoff 1957
	Spermophilus tereticaudus	Morlan & Hoff 1957
	Spermophilus variegatus	Ritzi & Sparks 2002
Trichodectidae		
Bovicola ovis	*Ammotragus lervia*	Richerson et al. 1992
Geomydoecus expansus	*Cratogeomys castonops*	Richerson et al. 1992
Neotrichodectes thoracicus	*Bassariscus astutus*	Custer & Pence 1978
SIPHONAPTERA		
Hystrichopsyllidae		
Anomiopsyllus hiemalis	*Neotoma micropus*	Richerson et al. 1992
	Neotoma albigula	Richerson et al. 1992
Anomiopsyllus novomexicanensis	*Dipodomys ordii*	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
Anomiopsyllus nundatus	*Bassariscus astutus*	Custer & Pence 1978
	Neotoma micropus	Richerson et al. 1992
Atyphloceras m. multidenticulatum	*Dipodomys spectabilis*	Whitaker et al. 1993

APPENDIX 1—*continued*

Ectoparasite	Host	Citation
Ctenophthalmus caballeroi	*Microtus mexicanus*	Timm 1985
Ctenophthalmus pseudagyrtes	*Neotoma micropus*	Traub 1950
Megarthroglossus bisetis	*Dipodomys spectabilis*	Whitaker et al. 1993
Meringis agilis	*Chaetodipus nelsoni*	Whitaker et al. 1993
	Chaetodipus penicillatus	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Meringis altipectin	*Dipodomys merriami*	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
Meringis arachis	*Onychomys arenicola*	Richerson et al. 1992
	Dipodomys spectabilis	Whitaker et al. 1993
Meringis bilsingi	*Dipodomys merriami*	Whitaker et al. 1993
	Dipodomys ordii	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
Meringis dipodomys	*Dipodomys ordii*	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Meringis nidi	*Dipodomys merriami*	Whitaker et al. 1993
	Dipodomys ordii	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
Meringis penicillatus	*Chaetodipus penicillatus*	Van Pelt 1995
	Dipodomys merriami	Van Pelt 1995
	Dipodomys nelsoni	Van Pelt 1995
Meringis rectus	*Dipodomys merriami*	Whitaker et al. 1993
	Dipodomys ordii	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Meringis vitabilis	*Dipodomys merriami*	Richerson et al. 1992; Van Pelt 1995
Stenoponia ponera	*Microtus mexicanus*	Timm 1985
Leptopsyllidae		
Peromyscopsylla hesperomys	*Onychomys arenicola*	Macaluso 1996
	Peromyscus leucopus	Richerson et al. 1992; Whitaker 1968

APPENDIX 1—*continued*

Ectoparasite	Host	Citation
P. hesperomys (cont)	*Peromyscus maniculatus*	Richerson et al. 1992; Whitaker 1968
	Peromyscus pectoralis	Richerson et al. 1992
Ischnopsyllidae		
Hormopsylla trux	*Eumops perotis*	Whitaker & Easterla 1975
	Nyctinomops macrotis	Whitaker & Easterla 1975
Myodopsylla collinsi	*Antrozous pallidus*	Ritzi et al. 2001
	Myotis velifer	Ritzi et al. 2001; Whitaker et al. 1975
	Myotis yumanensis	Ritzi et al. 2001; Whitaker et al. 1975
Myodopsylla gentilis	*Antrozous pallidus*	Whitaker et al. 1975
	Leptonycteris nivalis	Whitaker et al. 1975
	Mormoops megalophylla	Whitaker et al. 1975
	Myotis velifer	Whitaker et al. 1975
	Myotis yumanensis	Ritzi et al. 2001; Whitaker et al. 1975
	Nyctinomops macrotis	Whitaker et al. 1975
	Tadarida brasiliensis	Whitaker et al. 1975
Sternopsylla texana	*Leptonycteris nivalis*	Whitaker et al. 1975
	Tadarida brasiliensis	Jameson 1959; Ritzi et al. 2001; Whitaker et al. 1975
Ceratophyllidae		
Dactylopslla percernis	*Bassariscus astutus*	Richerson et al. 1992
	Chaetodipus hispidus	Richerson et al. 1992
	Cratogeomys castanops	Richerson et al. 1992
	Onychomys arenicola	Richerson et al. 1992
Malaraeus sinomus	*Bassariscus astutus*	Custer & Pence 1978
Monopsyllus exilis	*Onychomys arenicola*	Macaluso 1996; Richerson et al. 1992
	Spermophilus spilosoma	Richerson et al. 1992
Monopsyllus wagneri	*Peromyscus maniculatus*	Richerson et al. 1992; Whitaker 1968
Nosopsyllus faciatus	*Rattus rattus*	Pratt & Good 1954

APPENDIX 1–*continued*

Ectoparasite	Host	Citation
Opisocrostis bruneri	*Neotoma micropus*	Richerson et al. 1992
	Peromyscus maniculatus	Richerson et al. 1992
	Peromyscus pectoralis	Richerson et al. 1992
Opisocrostis hirsutus	*Onychomys arenicola*	Richerson et al. 1992
Orchopeas leucopus	*Chaetodipus hispidus*	Whitaker et al. 1993
	Neotoma albigula	Richerson et al. 1992
	Onychomys arenicola	Macaluso 1996
	Peromyscus maniculatus	Richerson et al. 1992; Whitaker 1968
Orchopeas sexdentatus	*Bassariscus astutus*	Custer & Pence 1978; Richerson et al. 1992
	Canis latrans	Richerson et al. 1992
	Conepatus leuconotus	Richerson et al. 1992
	Dipodomys merriami	Richerson et al. 1992
	Neotoma albigula	Richerson et al. 1992
	Neotoma micropus	Richerson et al. 1992
	Onychomys arenicola	Macaluso 1996; Richerson et al. 1992
	Peromyscus boylii	Richerson et al. 1992
	Peromyscus leucopus	Richerson et al. 1992
	Peromyscus maniculatus	Richerson et al. 1992
	Peromyscus pectoralis	Richerson et al. 1992
	Spermophilus spilosoma	Richerson et al. 1992
	Spilogale gracilis	Richerson et al. 1992
	Sylvilagus audubonii	Richerson et al. 1992
Oropsylla aridus	*Dipodomys merriami*	Whitaker et al. 1993
	Dipodomys ordii	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
Oropsylla fota	*Chaetodipus hispidus*	Whitaker et al. 1993
	Dipodomys ordii	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
Oropsylla montana	*Ammospermophilus interpres*	Richerson et al. 1992
	Spermophilus variegatus	Richerson et al. 1992; Ritzi & Sparks 2002

APPENDIX 1—*continued*

Ectoparasite	Host	Citation
Pleochaetis equatoris	*Microtus mexicanus*	Traub 1950
Pleochaetis silvynus	*Microtus mexicanus*	Timm 1985
Thrassis bacchi	*Spermophilus sp.*	Van Pelt 1995
Thrassis pansus	*Onychomys arenicola*	Fain 1978
	Neotoma micropus	Richerson et al. 1992
Thrassis fotus	*Onychomys arenicola*	Prince 1944; Richerson et al. 1992
	Spermophilus sp.	Van Pelt 1995
Pulicidae		
Echidnophaga gallinacea	*Ammospermophilus interpres*	Richerson et al. 1992
	Bassariscus astutus	Custer & Pence 1978; Richerson et al. 1992
	Canis latrans	Richerson et al. 1992
	Chaetodipus hispidus	Richerson et al. 1992
	Dipodomys merriami	Richerson et al. 1992; Whitaker et al. 1993
	Dipodomys ordii	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Lepus californicus	Richerson et al. 1992
	Mus musculus	Richerson et al. 1992
	Neotoma micropus	Richerson et al. 1992
	Peromyscus boylii	Richerson et al. 1992
	Peromyscus maniculatus	Richerson et al. 1992
	Sigmodon hispidus	Richerson et al. 1992
	Spermophilus spilosoma	Richerson et al. 1992
	Spermophilus variegatus	Richerson et al. 1992; Ritzi & Sparks 2002
	Sylvilagus audubonii	Richerson et al. 1992
	Sylvilagus floridanus	Richerson et al. 1992
	Rattus rattus	Pratt & Good 1954
	Urocyon cinereoargenteus	Richerson et al. 1992

Appendix 1–*continued*

Ectoparasite	Host	Citation
Euhoplopsyllus glacialis affinis	*Chaetodipus hispidus*	Whitaker et al. 1993
	Dipodomys merriami	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Lepus californicus	Richerson et al. 1992
	Liomys irroratus	Whitaker et al. 1993
	Peromyscus maniculatus	Richerson et al. 1992
	Peromyscus pectoralis	Richerson et al. 1992
	Sylvilagus floridanus	Richerson et al. 1992
Hoplopsyllus affinis	*Onychomys arenicola*	Macaluso 1996
Hoplopsyllus anomalus	*Ammospermophilus interpres*	Richerson et al. 1992
	Peromyscus pectoralis	Richerson et al. 1992
	Spermophilus variegates	Richerson et al. 1992
Pulex simulans	*Bassariscus astutus*	Custer & Pence 1978; Richerson et al. 1992
	Canis latrans	Richerson et al. 1992
	Conepatus leuconotus	Richerson et al. 1992
	Dipodomys spectabilis	Whitaker et al. 1993
	Lepus californicus	Richerson et al. 1992
	Microtus mexicanus	Timm 1985
	Neotoma albigula	Richerson et al. 1992
	Neotoma micropus	Richerson et al. 1992
	Spermophilus spilosoma	Richerson et al. 1992
	Spilogale gracilis	Richerson et al. 1992
	Sylvilagus audubonii	Richerson et al. 1992
	Sylvilagus floridanus	Richerson et al. 1992
	Urocyon cinereoargenteus	Richerson et al. 1992
Rhynochopsyllus pulex	*Eumops perotis*	Whitaker & Easterla 1975
Xenopsyllus cheopis	*Mus musculus*	Richerson et al. 1992
	Rattus rattus	Pratt & Good 1954

APPENDIX 1–*continued*

Ectoparasite	Host	Citation
Rhopalopsyllidae		
Polygenis gwyni	*Bassariscus astutus*	Custer & Pence 1978
	Dipodomys spectabilis	Whitaker et al. 1993
	Liomys irroratus (55	Whitaker et al. 1993
	Sigmodon hispidus (33	Richerson et al. 1992
Polygenis martinezbaezi	*Liomys irroratus* (55)	Whitaker et al. 1993
IXODIDA		
Argasidae		
Ornithodorus concanensis	"bat"	Cooley & Kohls 1944
Ornithodorus mormoops	*Mormoops megalophylla*	Whitaker & Easterla 1975
Ornithodorus rossi	*Antrozous pallidus*	Whitaker & Easterla 1975
	Corynorhinus townsendii	Whitaker & Easterla 1975
	Eptesicus fuscus	Wenzel 1970
	Pipistrellus hesperus	Whitaker & Easterla 1975
Ornithodorus kelleyi	*Antrozous pallidus*	Ritzi et al. 2001; Whitaker & Easterla 1975
	Myotis yumanensis	Ritzi et al. 2001
Ornithodorus stageri	*Nyctinomops macrotis*	Whitaker & Easterla 1975
	Tadarida brasilienisis	Ritzi et al. 2001; Whitaker & Easterla 1975
Ornithodorus talaje	*Chaetodipus hispidus*	Whitaker et al. 1993
	Liomys irroratus	Whitaker et al. 1993
	Neotoma sp.	Cooley & Kohls 1944
Ornithodorus turicata	*Dipodomys sp.*	Cooley & Kohls 1944
	Spermophilus sp.	Cooley & Kohls 1944
	Neotoma sp.	Cooley & Kohls 1944
Ornithodorus yumatensis	*Antrozous pallidus*	Dooley et al. 1976
	Eptesicus fuscus	Dooley et al. 1976
	Pipistrellus hesperus	Dooley et al. 1976
	Tadarida brasilensis	Dooley et al. 1976
Otobius megnini	*Ammotragus lervia*	Richerson et al. 1992
	Lepus californicus	Cooley & Kohls 1944
	Sylvilagus audubonii	Cooley & Kohls 1944

APPENDIX 1–*continued*

Ectoparasite	Host	Citation
Ixodidae		
Amblyomma americanum	*Bassaricus astutus*	Custer & Pence 1978; Richerson et al. 1992
	Lepus californicus	Richerson et al. 1992
	Peromyscus maniculatus	Richerson et al. 1992
	Sylvilagus audubonii	Richerson et al. 1992
Amblyomma inornatum	*Canis latrans*	Richerson et al. 1992
	Lepus californicus	Richerson et al. 1992
	Neotoma micropus	Richerson et al. 1992
	Sigmodon hispidus	Richerson et al. 1992
Dermacenter albipictus	*Ammotragus lervia*	Richerson et al. 1992
Dermacenter parumapeterus	*Dipodomys ordii*	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Peromyscus maniculatus	Richerson et al. 1992
Dermacenter variabilis	*Bassariscus astutus*	Custer & Pence 1978; Richerson et al. 1992
	Dipodomys merriami	Richerson et al. 1992
	Lepus californicus	Richerson et al. 1992
	Sylvilagus audubonii	Richerson et al. 1992
Haemaphysalis leporispalustris	*Bassariscus astutus*	Custer & Pence 1978
	Dipodomys ordii	Whitaker et al. 1993
	Lepus californicus	Richerson et al. 1992
	Sylvilagus audubonii	Richerson et al. 1992
Ixodes conepati	*Bassariscus astutus*	Custer & Pence 1978
Ixodes cookei	*Bassariscus astutus*	Richerson et al. 1992
	Conepatus leuconotus	Richerson et al. 1992
	Spilogale gracilis	Richerson et al. 1992
Ixodes eadsi	*Liomys irroratus*	Whitaker et al. 1993
Ixodes scapularis	*Bassariscus astutus*	Richerson et al. 1992
	Lepus californicus	Richerson et al. 1992
	Sylvilagus audubonii	Richerson et al. 1992

APPENDIX 1–*continued*

Ectoparasite	Host	Citation
I. scapularis (cont)	*Urocyon inereoargenteus*	Richerson et al. 1992
Ixodes woodi	*Neotoma micropus*	Richerson et al. 1992
Rhipicephalus sanguineus	*Canis latrans*	Richerson et al. 1992
	Dipodomys merriami	Richerson et al. 1992
	Lepus californicus	Richerson et al. 1992
	Onychomys arenicola	Macaluso 1996
	Sylvilagus audubonii	Richerson et al. 1992
MESOSTIGMATA		
Laelapidae		
Androlaelaps fahrenholzi	*Bassariscus astutus*	Custer & Pence 1978
	Chaetodipus hispidus	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Liomys irroratus	Whitaker et al. 1993
	Microtus mexicanus	Timm 1985
	Spermophilus variegatus	Ritzi & Sparks 2002
Androlaelaps grandiculata	*Chaetodipus hispidus*	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Echinonyssus breviseta	*Bassariscus astutus*	Custer & Pence 1978
	Microtus mexicanus	Timm 1985
Echinonyssus hilli	*Perognathus flavus*	Whitaker et al. 1993
Echinonyssus incomptis	*Dipodomys ordii*	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
Echinonyssus liomys	*Liomys irroratus*	Whitaker et al. 1993
Echinonyssus neotomae	*Liomys irroratus*	Whitaker et al. 1993
Echinonyssus perognathi	*Chaetodipus hispidus*	Whitaker et al. 1993
	Liomys irroratus	Whitaker et al. 1993
Echinonyssus staffordi	*Bassariscus astutus*	Custer & Pence 1978
Echinonyssus tricanthus	*Dipodomys ordii*	Whitaker et al. 1993
Echinonyssus utahensis	*Microtus mexicanus*	Timm 1985

APPENDIX 1–*continued*

Ectoparasite	Host	Citation
Eubrachylaelaps crowei	*Dipodomys spectibilis*	Whitaker et al. 1993
Haemogamasus ambulans	*Microtus mexicanus*	Timm 1985
Haemogamasus reidi	*Microtus mexicanus*	Timm 1985
Hypoaspis leviculus	*Chaetodipus hispidus*	Whitaker et al. 1993
Ischyropoda armatus	*Dipodomys ordii*	Whitaker et al. 1993
	Dipodomys spectibilis	Whitaker et al. 1993
Ischyropoda spiniger	*Chaetodipus penicillatus*	Whitaker et al. 1993
Laelaps kochi	*Microtus mexicanus*	Timm 1985
Steptolaelaps liomydis	*Liomys irroratus*	Whitaker et al. 1993
Macronyssidae		
Chiroptonyssus robustipes	*Mormoops megalophylla*	Whitaker & Easterla 1975
	Myotis californicus	Dooley et al. 1976
	Myotis velifer	Ritzi et al. 2001
	Nyctinomops macrotis	Whitaker & Easterla 1975
	Tadarida brasiliensis	Jameson 1959; Ritzi et al. 2001; Whitaker & Easterla 1975
Chiroptonyssus haematophagus	*Eumops perotis*	Whitaker & Easterla 1975
	Nyctinomops femorosacca	Whitaker & Easterla 1975
Chiroptonyssus venezolanus	*Nyctinomops femorosacca*	Ritzi et al. 2001; Whitaker & Easterla 1975
	Nyctinomops macrotis	Ritzi et al. 2001; Whitaker & Easterla 1975
	Pipistrellus hesperus	Ritzi et al. 2001
Crytonyssus desultorius	*Eptesicus fuscus*	Ritzi et al. 2001
	Myotis velifer	Ritzi et al. 2001
	Myotis yumanensis	Ritzi et al. 2001; Whitaker & Easterla 1975
	Pipistrellus hesperus	Ritzi et al. 2001
Cryptonyssus sp.	*Euderma maculatum*	Whitaker & Easterla 1975

APPENDIX 1—*continued*

Ectoparasite	Host	Citation
Steatonyssus antrozoi	*Antrozous pallidus*	Dooley et al. 1976; Ritzi et al. 2001; Whitaker & Easterla 1975
	Myotis yumanensis	Whitaker & Easterla 1975
Steatonyssus emarginatus	*Pipistrellus hesperus*	Dooley et al. 1976; Whitaker & Easterla 1975
Steatonyssus furmani	*Lasiurus cinereus*	Ritzi et al. 2001; Whitaker & Easterla 1975
Steatonyssus occidentalis	*Eptesicus fuscus*	Dooley et al. 1976; Whitaker & Easterla 1975
	Myotis velifer	Ritzi et al. 2001
	Nyctinomops macrotis	Whitaker & Easterla 1975
	Tadarida brasiliensis	Whitaker & Easterla 1975
Macronyssus crosbyi	*Myotis velifer*	Ritzi et al. 2001; Whitaker & Easterla 1975
Macronyssus longisetosus	*Corynorhinus townsendii*	Whitaker & Easterla 1975
Ornithonyssus bacoti	*Chaetodipus hispidus*	Whitaker et al. 1993
	Liomys irroratus	Whitaker et al. 1993
	Rattus rattus	Price et al. 2003
Ornithonyssus sylviarum	*Liomys irroratus*	Whitaker et al. 1993
Spinturnicidae		
Periglischrus strandtmanni	*Mormoops megalophylla*	Jameson 1959
Periglischrus vargasi	*Leptonycteris nivalis*	Whitaker & Easterla 1975
Spinturnix americanus	*Myotis thysanodes*	Ritzi et al. 2001; Whitaker & Easterla 1975
	Myotis velifer	Ritzi et al. 2001; Whitaker & Easterla 1975
	Myotis volans	Ritzi et al. 2001
	Myotis yumanensis	Ritzi et al. 2001; Whitaker & Easterla 1975
Spinturnix bakeri	*Eptesicus fuscus*	Whitaker & Easterla 1975
Spinturnix carloshoffmani	*Myotis velifer*	Ritzi et al. 2001

APPENDIX 1—*continued*

Ectoparasite	Host	Citation
Spinturnix orri	*Antrozous pallidus*	Ritzi et al. 2001; Whitaker & Easterla 1975
PROSTIGMATA		
Leeuwenhoekiidae		
Odontacarus tubercularis	*Liomys irroratus*	Whitaker et al. 1993
Wagenaaria similes	*Mormoops megalophylla*	Whitaker & Easterla 1975
Whartonia carpenteri	*Antrozous pallidus*	Dooley et al. 1976
	Pipistrellus hesperus	Dooley et al. 1976
Whartonia perplexa	*Antrozous pallidus*	Whitaker & Easterla 1975
	Eptesicus fuscus	Ritzi et al. 2001; Whitaker & Easterla 1975
	Eptesicus fuscus	Ritzi et al. 2001; Whitaker & Easterla 1975
	Myotis velifer	Ritzi et al. 2001;
Xenodontacarus plumosus	*Liomys irroratus*	Whitaker et al. 1993
Myobiidae		
Acanthophthirius caudata	*Eptesicus fuscus*	Whitaker & Easterla 1975
	Myotis velifer	Ritzi et al. 2001
Acanthophthirius sp	*Eumops perotis*	Whitaker & Easterla 1975
Ewingana doreyae	*Nyctinomops macrotis*	Whitaker & Easterla 1975
Ewingana longa	*Tadarida brasiliensis*	Jameson 1959; Ritzi et al. 2001
Phyllostomyobia leptonycteris	*Leptonycteris nivalis*	Prince 1944
Radfordia hylandi	*Microtus mexicanus*	Timm 1985
Trombiculidae		
Albeckia senase	*Antrozous pallidus*	Ritzi et al. 2001
	Pipistrellus hesperus	Ritzi et al. 2001
Dermadelema sleeperi	*Dipodomys merriami*	Whitaker et al. 1993
Euschoengastia bigenuala	*Liomys irroratus*	Whitaker et al. 1993
Euschoengastia eadsi	*Bassariscus astutus*	Custer & Pence 1978

APPENDIX 1–*continued*

Ectoparasite	Host	Citation
Euschoengastoides arizonae	*Chaetodipus nelsoni*	Whitaker et al. 1993
	Chaetodipus penicillatus	Whitaker et al. 1993
	Dipodomys merriami	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Euschoengastoides hoplai	*Chaetodipus nelsoni*	Whitaker et al. 1993
	Chaetodipus penicillatus	Whitaker et al. 1993
	Dipodomys merriami	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Euschoengastiodes imperfectus	*Chaetodipus penicillatus*	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Euschoengastoides loomisi	*Chaetodipus hispidus*	Whitaker et al. 1993
	Chaetodipus nelsoni	Whitaker et al. 1993
	Chaetodipus penicillatus	Whitaker et al. 1993
	Dipodomys merriami	Whitaker et al. 1993
	Liomys irroratus	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Euschoengastoides neotomae	*Chaetodipus nelsoni*,	Whitaker et al. 1993
	Chaetodipus penicillatus	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Perognathus flavescens	Whitaker et al. 1993
Eutrombicula alfreddugesi	*Dipodomys merriami*	Whitaker et al. 1993
	Liomys irroratus	Whitaker et al. 1993
Hexiodinis allredi	*Chaetodipus nelsoni*	Whitaker et al. 1993
	Chaetodipus penicillatus	Whitaker et al. 1993
	Dipodomys merriami	Whitaker et al. 1993
	Liomys irroratus	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993

APPENDIX 1–*continued*

Ectoparasite	Host	Citation
Hexiodinis breviseta	*Perognathus flavus*	Whitaker et al. 1993
Hexiodinis harveyi	*Chaetodipus penicillatus*	Whitaker et al. 1993
	Dipodomys merriami	Whitaker et al. 1993
	Dipodomys ordii	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Hyponeocula arenicola	*Chaetodipus penicillatus*	Whitaker et al. 1993
	Dipodomys merriami	Whitaker et al. 1993
	Dipodomys nelsoni	Whitaker et al. 1993
	Dipodomys spectabilis	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Kayella lacerta	*Chaetodipus nelsoni*	Whitaker et al. 1993
	Chaetodipus penicillatus	Whitaker et al. 1993
	Liomys irroratus	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Leptotrombidium panamense	*Chaetodipus nelsoni*	Whitaker et al. 1993
	Chaetodipus penicillatus	Whitaker et al. 1993
	Dipodomys merriami	Whitaker et al. 1993
	Liomys irroratus	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Odontacarus tubercluaris	*Liomys irroratus*	Whitaker et al. 1993
Otorhinophila baccusi	*Chaetodipus nelsoni*	Whitaker et al. 1993
	Chaetodipus penicillatus	Whitaker et al. 1993
	Dipodomys merriami	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Otorhinophila desertorum	*Chaetodipus penicillatus*	Whitaker et al. 1993
Otorhinophila intrasola	*Chaetodipus penicillatus*	Whitaker et al. 1993
Otorhinophila parvisola	*Chaetodipus penicillatus*	Whitaker et al. 1993
Otorhinophila xerophila	*Chaetodipus penicillatus*	Whitaker et al. 1993

APPENDIX 1–*continued*

Ectoparasite	Host	Citation
Neotrombicula microti	*Microtus mexicanus*	Timm 1985
Parasecia gurneyi	*Dipodomys merriami*	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Pseudoschoengastia apista	*Bassariscus astutus*	Custer & Pence 1978
Pseudoschoengastia audyi	*Liomys irroratus*	Whitaker et al. 1993
Pseudoschoengastia farneri	*Liomys irroratus*	Whitaker et al. 1993
	Perognathus flavus	Whitaker et al. 1993
Pseudoschoengastia hungerfordi	*Chaetodipus hispidus*	Whitaker et al. 1993
	Chaetodipus nelsoni	Whitaker et al. 1993
Tecomatlana texana	*Nyctinomops macrotis*	Whitaker & Easterla 1975
ASTIGMATA		
Glycyphagidae		
Glycyphagus hypudaei	*Bassariscus astutus*	Custer & Pence 1978
Glycyphagus liomys	*Liomys irroratus*	Whitaker et al. 1993
Metalabidophorus liomys	*Liomys irroratus*	Whitaker et al. 1993
Listrophoridae		
Geomylichus brevispinosus	*Chaetodipus penicillatus*	Fain et al. 1978; Whitaker et al. 1993
Geomylichus dipodomius	*Dipodomys ordii*	Whitaker et al. 1993
	Dipodomys phillipsi	Fain & Whitaker 1987; Fain et al. 1978; Whitaker et al. 1993
	Dipodomys spectabilis	Fain & Whitaker 1987; Whitaker et al. 1993
Geomylichus inaequalis	*Chaetodipus hispidus*	Whitaker et al. 1993
Geomylichus klebergi	*Sigmodon hispidus*	Fain et al. 1978
Geomylichus multistriatus	*Dipodomys merriami*	Fain et al. 1988; Whitaker et al. 1993
Geomylichus postscutatus	*Liomys irroratus*	Whitaker et al. 1993
Geomylichus texanus	*Dipodomys merriami*	Fain et al. 1988; Fain et al. 1978; Whitaker et al. 1993

APPENDIX 1–*continued*

Ectoparasite	Host	Citation
Listrophorus mexicanus	*Microtus mexicanus*	Timm 1985
Rosensteiniidae		
Nycteriglyphus texanus	*Corynorhinus townsendii*	Oconnor et al. 1977; Whitaker & Easterla 1975
	Leptonycteris nivalis	Oconnor et al. 1977; Whitaker & Easterla 1975
	Myotis velifer	Oconnor et al. 1977; Whitaker & Easterla 1975
	Myotis yumanensis	Oconnor et al. 1977; Whitaker & Easterla 1975
	Tadarida brasiliensis	Oconnor et al. 1977; Whitaker & Easterla 1975