Human–Wildlife Interactions 8(2):251–260, Fall 2014

Wildlife strikes with U.S. military rotary-wing aircraft deployed in foreign countries

Brian E. Washburn, U.S. Department of Agriculture, Wildlife Services' National Wildlife Research Center, 6100 Columbus Avenue, Sandusky, OH 44870, USA *brian.e.washburn@aphis.usda.gov*

Paul J. Cisar, Logistics Division, U.S. Army Aberdeen Test Center, Aberdeen Proving Grounds, MD 21005, USA

Travis L. DeVault, U.S. Department of Agriculture, Wildlife Services' National Wildlife Research Center, 6100 Columbus Avenue, Sandusky, OH 44870, USA

Abstract: During recent decades, rotary-wing aircraft (helicopters) within the U.S. Department of Defense (e.g., U.S Army and U.S. Air Force) have been deployed overseas to conduct a variety of noncombat and combat missions. Our objective was to conduct a comprehensive analysis of wildlife (birds, bats, insects) strikes with U.S. Army and U.S. Air Force rotary-wing aircraft during overseas deployments. We acquired all available wildlife strike information involving U.S. Army and U.S. Air Force military rotary-wing aircraft engaged in flight operations associated with U.S. military bases around the world during 1990 to 2011. Wildlife strikes with military rotary-wing aircraft occurred in >31 foreign countries. Almost two-thirds of wildlife strikes to U.S. Army aircraft occurred during deployments in the Middle East (e.g., Iraq), whereas, strikes to U.S. Air Force aircraft occurred most frequently in Afghanistan and the Middle East. Month, time of day, and location (i.e., on airfield or off airfield) influenced the frequency of wildlife strikes. Wildlife strikes occurred most frequently when aircraft were traveling en route or were engaged in terrain flight. Larks, doves, pigeons, and various perching birds were the species most frequently struck by military aircraft. Wildlife strike records related to U.S. military overseas operations represent a unique source of ornithological information from areas of military conflict.

Key words: Afghanistan, helicopters, human–wildlife conflicts, Iraq, military, rotary-wing aircraft, wildlife strikes

During the last 2 decades, a great deal of armed conflict, and political upheaval has occurred in the Middle East (e.g., Iraq) and south-central Asia (e.g., Afghanistan), much of which has involved the deployment of U.S. military aircraft. Rotary-wing aircraft (i.e., helicopters) have carried out numerous noncombat and combat missions during Operation Desert Storm in Kuwait and Iraq during 1990 to 1991, Operation Enduring Freedom (2001 to 2014) in Afghanistan, and Operation Iraqi Freedom in Iraq during 2003 to 2010. Air crews of military rotary-wing aircraft face many hazards to flight safety, including physical hazards (e.g., wires, buildings), weather, human factors (e.g., fatigue), and hostile actions (e.g., antiaircraft weaponry) that result in damage to aircraft and human injuries and fatalities (Couch and Lindell 2010, U.S. Army 2012). Collisions with wildlife represent an important, but unstudied, physical hazard to military rotary-wing aircraft used in conducting overseas flight operations. Wildlife collisions with aircraft (wildlife strikes) pose increasing risks and economic losses to civil and military aviation worldwide (Thorpe 2010, Dolbeer et al. 2012, DeVault et al. 2013).

Although rotary-wing aircraft conduct essential missions during overseas deployments, no assessment of wildlife strikes to military rotary-wing aircraft during these operations has been conducted. The objectives of this project were to conduct a comprehensive analysis of data available from U.S. Army and U.S. Air Force on wildlife strikes with rotary-wing aircraft during flight operations outside of the USA.

Methods

We acquired all available wildlife strike records for U.S. Army rotary-wing aircraft during 1990 to 2011 from the U.S. U.S. Army Combat Readiness-Safety Center and for U.S. Air Force rotary-wing aircraft during 1994 to 2011 from the U.S. Air Force Safety Center. We created a new database and conducted a line-by-line review of each wildlife strike record to ensure data integrity and consistency. Due to the diverse nature of the data fields contained

within the 2 military databases, we also extracted data from narrative records, accident reports, and incident information (e.g., pilot commentary). When necessary, we recoded or classified wildlife strike information to allow for consistency in terminology categories between the 2 military service strike records for variables (e.g., the phase of flight the aircraft was in when the bird strike occurred).

We parsed our database to include only wildlife strikes to U.S. Army and U.S. Air Force military rotary-wing aircraft engaged in flight operations during overseas deployments (i.e., outside of the USA) associated with U.S. military bases around the world. Notably, these flight operations were conducted during training exercises, peace keeping operations, and recognized in-theater combat operations.

We determined the time of day each wildlife strike event occurred based on the local time reported in strike records. Wildlife strikes occurring between 0800 and 1800 hours local time were categorized as day, while strikes between 2000 to 0600 hours were categorized as night events. Dawn strike events occurred during 0600 to 0800 hours, and dusk events occurred during 1800 to 2000 hours.

Phase of flight was defined as the phase of flight the aircraft was in at the time the wildlife strike occurred (Federal Aviation Administration 2000, U.S. Army 2012). Aircraft in the en route phase of flight were flying at an altitude of 305 m above ground level (AGL) or higher. Rotary-wing aircraft that were flying (moving forward) at an altitude of <305 m AGL were classified as being in-terrain flight. Hovering rotary-wing aircraft were off the ground (but <305 m AGL) and stationary (i.e., no horizontal movement). Aircraft on-approach were in early stages of the landing process (≥30 m AGL and moving forward), typically on or over an airfield. Landing rotary-wing aircraft were in the final stages of landing and were <30 m AGL. Rotary-wing aircraft that were taxiing were moving along the ground or just above the ground (<3 m AGL) in a transition from 1 part of the airfield to another (e.g., traversing from the hanger to an active helipad). Aircraft in the take-off phase were in the process of leaving the ground and were ascending upward (but <30 m AGL). Rotary-wing aircraft in the climb-out phase were in the later stages of taking off (≥30 m AGL and moving forward).

We defined a wildlife strike event with a rotary-wing aircraft as a damaging strike by bird, bat, or insect if there was any amount of damage to the aircraft reported. Damaging wildlife strikes varied greatly in the amount of actual damage incurred, ranging from minor abrasions found on the airframe or an aircraft component to the complete destruction of an aircraft engine.

Previous evaluations of wildlife strikes with civilian fixed-wing aircraft (Dolbeer et al. 2006) and rotary-wing aircraft (Washburn et al. 2013, Washburn et al. 2014) have shown that important patterns might exist among wildlife strikes that occur within airport environments compared to those that occur away from airports and military airfields. For each wildlife strike, the reported location of the strike event (if known) was determined to be on-airfield if the aircraft was within the horizontal delineation of an airfield when the strike occurred. Off-airfield strikes were defined as wildlife strike events that were reported to have occurred when the aircraft was not on or flying over an airfield (e.g., an aircraft traveling en route to a specified destination).

Animal analysis

Per required U.S. Air Force protocol, reports of strikes and remains of animals from all wildlife strikes with U.S. Air Force aircraft were sent to the Smithsonian Institution's Museum of Natural History, Feather Identification Laboratory. Wildlife strike identifications are made by the Smithsonian Institution staff using feathers (Laybourne and Dove 1994), hair (in the case of bats; Peurach et al. 2009), or DNA analysis (Dove et al. 2008). For each individual strike event, the wildlife involved was assigned to 1 of 20 groups (DeGraff et al. 1985, Kissling et al. 2011, Wielstra et al. 2011). In cases where the wildlife involved was identified to the species level, we assigned that wildlife strike to the appropriate group based on the species involved. Wildlife strike events involving >1 individual animal (e.g., a flock of birds) were enumerated the same as wildlife strike events that involved only 1 animal, because the number of individuals

Table 1. Number of reported wildlife strikes, by foreign country, involving rotary-wing aircraft for the U.S. Army (1990 to 2011) and U.S. Air Force (1990 to 2011).

Geographic area and country	U.S. Army	U.S. Air Force
Southwest Asia		
Afghanistan	12	177
Turkey	3	5
Persian Gulf		
Iraq	136	117
Kuwait	3	3
Saudi Arabia	6	1
Asia and Pacific Rim		
South Korea	28	35
Thailand	1	6
Japan		15
Philippines		2
Indonesia		2
Malaysia		1
Kwajalein Island	1	
Europe		
United Kingdom		61
Germany	13	1
Italy		5
Belgium	1	
Greece		1
Spain		1
Albania		2
Iceland		10
Latvia		1
Lithuania		1
Serbia	1	
Yugoslavia	1	
Central America		
Panama	13	3
Honduras	10	
Guatemala	3	
Ecuador	1	
San Salvador	1	
Africa		
Nigeria	1	
Somalia	3	
Other countries		13
Total	238	463

involved was not available for most reported wildlife strikes from the various databases.

Statistical analyses

Many of the earlier strike records were incomplete, and specific fields of information were missing or unknown; thus, sample sizes varied among variables and analyses. We used linear regression analyses, ANOVA, and *t*-tests to determine if significant differences occurred in the number of reported wildlife strikes among years and times of recognized theaters of combat operations (Zar 1996). We used chi-square analysis (Zar 1996) to compare the number of wildlife strikes with U.S. Army and U.S. Air Force rotary-wing aircraft among months and time of day. Descriptive statistics were used to quantify the frequency of wildlife strikes that occurred among the aircraft phases of flight. Data are presented as mean ±1 standard error (SE).

We also summarized wildlife strikes that occurred on-airfield separately from those that occurred during flight operations off-airfield. We used chi-square analysis (Zar 1996) to compare the number of bird strikes with U.S. Army and U.S. Air Force rotary-wing aircraft among wildlife groups for both on-airfield and off-airfield bird strikes.

Results

Characteristics of wildlife strikes

We found 701 wildlife strike records with military rotary-wing aircraft during deployments outside of the USA within the 2 military strike databases. Of these, 238 wildlife strikes involved U.S. Army aircraft, and 463 involved U.S. Air Force aircraft. Wildlife strikes with U.S. Army and U.S. Air Force rotary-wing aircraft occurred in >31 foreign countries (Table 1). Almost two-thirds (61%) of reported strikes to U.S. Army rotary-wing aircraft during deployments occurred in the Middle East (e.g., Iraq), whereas 13% and 12% occurred in Southeast Asia (e.g., South Korea) and Central America (e.g., Panama), respectively. Wildlife strikes to U.S. Air Force rotary-wing aircraft outside of the USA occurred most frequently in Afghanistan (38%), the Middle East (26%), Europe (18%), and Southeast Asia (13%).

During 1990 to 2011, an average (± SE) of 10.8 (± 2.4) reported wildlife strikes to U.S. Army rotary-wing aircraft occurred annually during flight operations outside of the USA (Figure 1). The annual number of reported wildlife strikes to U.S. Army aircraft during Operation Iraqi Freedom (2003 to 2009; 22.4 ± 4.1) was higher ($F_{2,19}$ = 14.8, P = 0.0002) than during times without combat theater operations (1992 to 2002; 5.1 ±

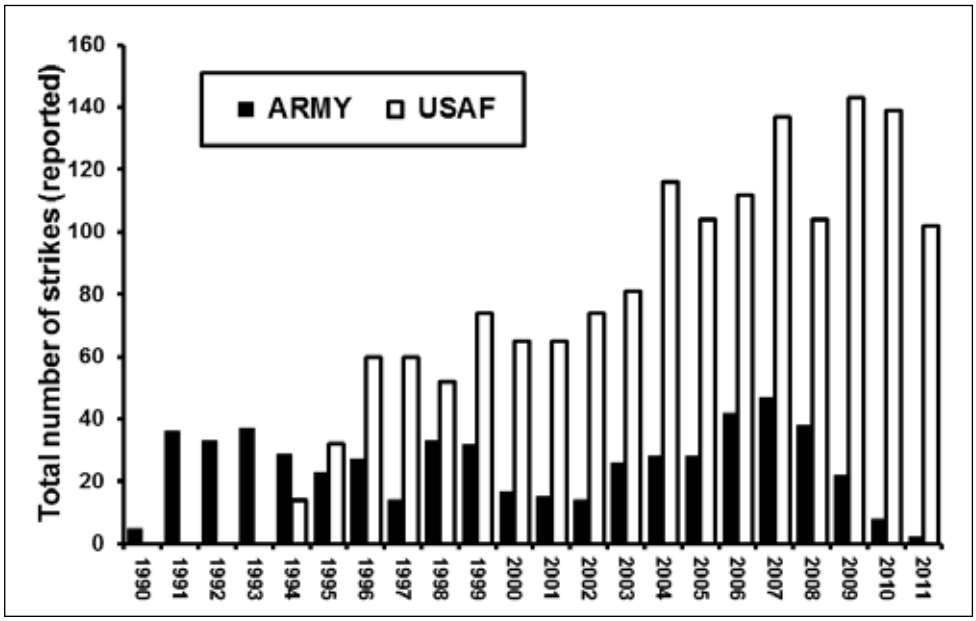

Figure 1. Number of reported wildlife strikes with U.S. Army (ARMY) rotary-wing aircraft during 1990 to 2011 and U.S. Air Force (USAF) rotary-wing aircraft during 1994 to 2011, each year, at locations outside of the USA.

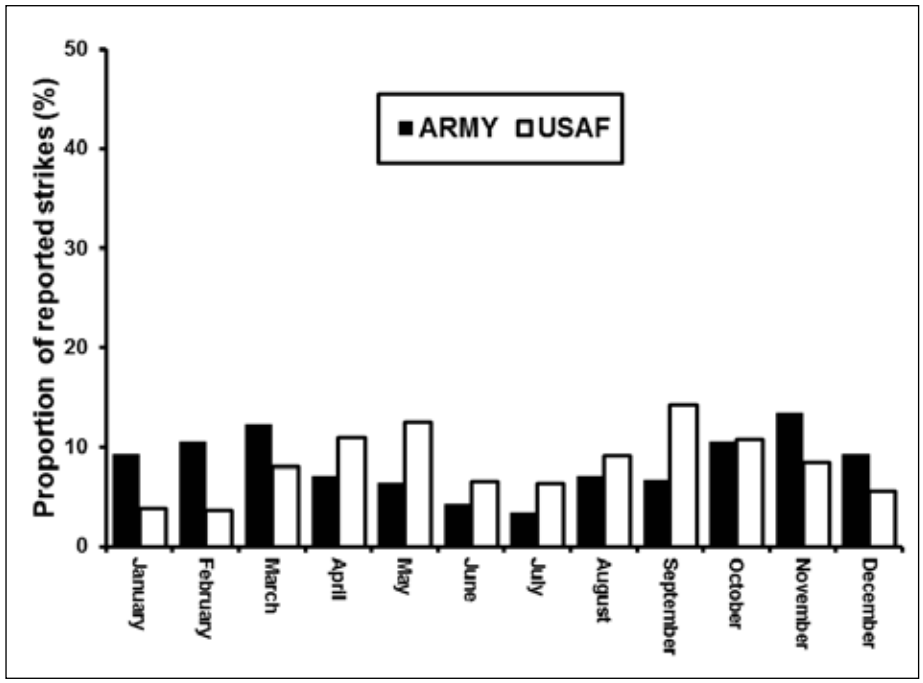

Figure 2. Proportion (%) of reported wildlife strikes, by month, for U.S. Army (ARMY) rotary-wing aircraft during 1990 to 2011 and U.S. Air Force (USAF) rotary-wing aircraft during 1994 to 2011, each year, at locations outside of the USA.

1.1 and 2010 to 2011; 1.0 ± 1.0). During 1990 to 2011, U.S. Army rotary-wing aircraft conducted an average of 1,008,645 (± 26,471) flight-hours per year (Washburn et al. 2014).

During 1994 to 2011, an average of 25.7 (± 5.3) reported wildlife strikes to U.S. Air Force rotary-wing aircraft occurred annually during flight operations outside of the USA (Figure 1).

Table 2. Proportion (%) of reported wildlife strikes, by phase of flight, for U.S. Army (n = 213) rotary-wing aircraft during 1990 to 2011 and for U.S. Air Force (n = 331) rotary-wing aircraft during 1994 to 2011 operating outside of the USA.

Phase of flight	U.S. Army	U.S. Air Force	U.S. Army and U.S. Air Force
En route	24.9	16.6	19.9
Terrain flight	60.6	67.5	64.7
Hovering	1.4	1.5	1.5
Approach	7.0	4.2	5.3
Pattern		3.3	2.0
Landing	0.9	2.7	2.0
Taxiing	0.5	0.9	0.7
Take-off	2.8	0.9	1.7
Climb-out	1.9	2.4	2.2

The annual number of wildlife strikes to U.S. Air Force aircraft remained constant across years (R^2 < 0.01; $F_{1,10}$ < 0.01, P = 0.97) without combat theatre operations (1994 to 2004), but increased (R^2 = 0.77; $F_{1,6}$ = 26.4, P = 0.02) during Operation Iraqi Freedom and Operation Enduring Freedom (2005 to 2010). The average number of reported wildlife strikes to U.S. Air Force rotary-wing aircraft during Operation Iraqi Freedom and Operation Enduring Freedom–Afghanistan (2005 to 2010; 46.3 ± 9.1) was >3.5 times higher (t_{16} = −4.6, P = 0.0003) than the average number of strikes that occurred during times without combat theater operations (1994 to 2004; 12.6 ± 1.5). During 1990 to 2011, U.S. Air Force rotary-wing aircraft conducted an average of 59,228 (±624) flight-hours per year (Washburn et al. 2014).

The number of reported wildlife strikes with military rotary-wing aircraft was similar across months (χ^2 = 15.5, df = 11, P = 0.16) for U.S. Army aircraft, but wildlife strikes to U.S. Air Force aircraft varied across months (χ^2 = 204.3, df = 11, P < 0.0001). The highest number of strikes occurred during spring (April and May) and fall (September), whereas, the lowest number was found in winter (December and January; Figure 2).

The proportion of reported wildlife strikes with U.S. Army (χ^2 = 30.4, df = 3, P < 0.0001) and U.S. Air Force (χ^2 = 247.9, df = 3, P < 0.0001) aircraft varied by time of day. For both U.S. Army and U.S. Air Force aircraft, few wildlife strikes occurred during dawn or dusk (Figure 3). Although the occurrence of wildlife strikes during day and night was similar for U.S. Air Force aircraft (χ^2 = 2.7, df = 1, P = 0.10), approximately 3 times more strikes were reported for U.S. Army aircraft (χ^2 = 125.2, df = 1, P = 0.0001) during the day compared to during the night (Figure 3). Wildlife strikes to U.S. Army and U.S. Air Force aircraft operating overseas occurred during all phases of aircraft flight, but they occurred most frequently (> 60%) when aircraft were engaged in in-terrain flight (Table 2).

Species of wildlife struck

During overseas flight operations, rotary-wing aircraft from the U.S. military were involved in strikes with 11 orders, 27 families, and 69 individual bird species. In addition, we found strikes with bats (Chiroptera), representing 3 families and 4 species (Table 3).

Not unexpectedly, military aircraft conducting flight operations in various parts of the world struck different wildlife species. Although U.S. Air Force rotary-wing aircraft conducting flight operations in Iraq during Operation Iraqi Freedom struck a variety of birds, pin-tailed sandgrouse (*Pterocles alchata*) and Eurasian skylarks (*Alauda arvensis*) were the most frequently recorded (i.e., accounting for 19 and 17%, respectively) of all strikes where the species involved was identified (Table 3). In addition to bird strikes, 2 bat strikes involving

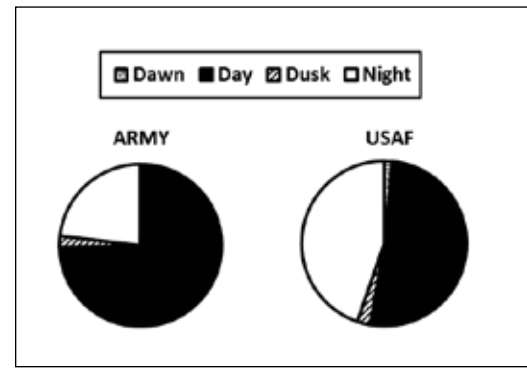

Figure 3. Proportion (%) of reported wildlife strikes, by time of day, with U.S. Army (ARMY) rotary-wing aircraft during 1990 to 2011 and U.S. Air Force (USAF) rotary-wing aircraft during 1994 to 2011 at locations outside of the USA.

Table 3. Number of birds and bats identified to species and involved in wildlife strikes with U.S. Air Force rotary wing aircraft operating in Iraq and Afghanistan during 1994 to 2011.

Order, family, and species	Country	
	Iraq	Afghanistan
Galliformes: Phasianidae		
Common quail (*Coturnix coturnix*)	5	3
Gruiformes: Rallidae		
Eurasian moorhen (*Gallinula chloropus*)	1	
Spotted crake (*Porzana porzana*)		1
Charadriiformes: Laridae		
Common tern (*Sterna hirundo*)	1	
Pterocliformes: Pteroclidae		
Pin-tailed sandgrouse (*Pterocles alchata*)	9	1
Columbiformes: Columbidae		
Common wood-pigeon (*Columba palumbus*)	1	
Eurasian collared-dove (*Streptopelia decaocto*)		1
Caprimulgiformes: Caprimulgidae		
Eygptian nightjar (*Caprimulgus aegyptius*)	1	
Apodiformes: Apodidae		
Alpine swift (*Apus melba*)		1
Common swift (*Apus apus*)	2	2
Little swift (*Apus affinius*)	2	2
Falconiformes: Falconidae		
Eurasian kestrel (*Falco tinnunculus*)	1	
Passeriformes: Laniidae		
Red-backed shrike (*Lanius collurio*)	1	
Passeriformes: Alaudidae		
Greater hoopoe (*Alaemon alaudipes*)		1
Hume's short-toed lark (*Calandrella acutirostris*)		1
Greater short-toed lark (*Calandrella brachydactyla*)		9
Lesser short-toed lark (*Calandrella rufescens*)		1
Horned lark (*Eremophila alpestris*)		1
Crested lark (*Galerida cristata*)	1	2
Eurasian skylark (*Alauda arvensis*)	8	11
Wood lark (*Lullula arborea*)	1	
Passeriformes: Acrocephalidae		
Blyth's reed-warbler (*Acrocephalus dumetorum*)		8
Sedge warbler (*Acrocephalus schoenobaenus*)	1	
Passeriformes: Locustellidae		
Common grasshopper-warbler (*Locustella naevia*)		1
Passeriformes: Hirundinidae		
Barn swallow (*Hirundo rustica*)	1	5
Passeriformes: Phylloscopidae		
Common chiffchaff (*Phylloscopus collybita*)	1	2
Yellow-browed warbler (*Phylloscopus inornatus*)		2
Willow warbler (*Phylloscopus trochilus*)	1	
Passeriformes: Sylviidae		
Lesser whitethroat (*Sylvia curruca*)		1
Sardinian warbler (*Sylvia melanocephala*)	1	
Passeriformes: Muscicapidae		
Bluethroat (*Luscinia svecica*)		1
Isabelline wheatear (*Oenanthe isabellina*)	1	
Passeriformes: Passeridae		
House sparrow (*Passer domesticus*)	5	10
Spanish sparrow (*Passer hispaniolensis*)		4
Passeriformes: Motacilliadae		
Citrine wagtail (*Motacilla citreola*)	1	
Tawny pipit (*Anthus campestris*)		1
Red-throated pipit (*Anthus cervinus*)	1	
Brown tree-pipit (*Anthus trivialis*)		1
Passeriformes: Emberizidae		
Ortolan bunting (*Emberiza hortulana*)	1	
Chiroptera: Molossidae		
European free-tailed bat (*Tadarida teniotis*)		1
Chiroptera: Rhinolophidae		
Greater mouse-tailed bat (*Rhinopoma microphyllum*)		3
Chiroptera: Vespertilionidae		
Common pipistrelle (*Pipistrellus pipistrellus*)		1
Kuhl's pipistrelle (*Pipistrellus kuhlii*)	2	2

Table 4. Number of all wildlife strikes and damaging strikes when the aircraft was reported as being on or over an airfield and as being off an airfield for U.S. Air Force rotary-wing aircraft operating outside of the USA during 1994 to 2011.[a]

Wildlife group	On-airfield		Off-airfield	
	All strikes	Damaging strikes	All strikes	Damaging strikes
Bats[b]	4		13	1
Blackbirds and starlings	2			
Corvids	1	1		
Doves and pigeons	5		19	9
Finches	1		1	
Gulls	6	2		
Herons, egrets, and ibises	2			
Larks	9		31	
Nightjars			1	1
Perching birds	9		27	
Pheasants and quails	3		6	
Raptors and vultures	3		1	
Shorebirds	3		5	
Sparrows			18	
Swallows	2		4	
Swifts and humming birds	5		11	
Terns	1			
Thrashers and thrushes	7	1	3	1
Warblers			20	
Waterbirds			1	
Waterfowl	6		1	
Unidentified spp.	132	5	100	9

[a]Wildlife species or group information is not identified within the U.S. Army wildlife strike database.
[b]Bats was comprised of common pipistrelles (*Pipistrellus pipistrellus*), European free-tailed bats (*Tadarida teniotis*), greater mouse-tailed bats (*Rhinopoma microphyllum*), Kuhl's pipistrelles (*Pipistrellus kuhlii*), and bats of unidentified species.

Kuhl's pipistrelles (*Pipistrellus kuhlii*) were reported in Iraq.

During Operation Enduring Freedom–Afghanistan, Eurasian skylarks (15% of all strikes where the species involved was identified), house sparrows (*Passer domesticus*; 14%), greater short-toed skylarks (*Calandrella brachydactyla;* 12%), and Blyth's reed-warblers (*Acrocephalus dumetorum;* 11%) were the species most commonly struck (Table 3). Also, 7 bat strikes (involving ≤3 different species) occurred with U.S. Air Force rotary-wing aircraft operating in Afghanistan.

Wildlife species struck on airfield. Among military rotary-wing aircraft strikes occurring on or over airfields (i.e., on airfield), 30% (709 of 230) contained information regarding the identity of the animal struck. Birds accounted for 98% of these strikes, and bats comprised the remaining 2%. During on-airfield flight operations, larks (e.g., Eurasian skylark), thrushes, thrashers, gulls (e.g., several species), and waterfowl (e.g., spot-billed duck [*Anas poecilorhyncha*]) were the most commonly struck wildlife groups by U.S. Air Force aircraft (Table 4). Limited information is available

regarding U.S. Army aircraft (97% of U.S. Army on-airfield strike records had no species-group information).

When only damaging on-airfield bird strikes are considered, 19% (5 of 27) contained information regarding the identity of the animal struck. Common black-headed gulls (*Chroicocephalus ridibundus*), mew gulls (*Larus canus*), black-billed magpies (*Pica pica*), thrashers (Mimidae), and thrushes (Turdidae) were involved in strikes that resulted in damage to U.S. Air Force aircraft operating within airfield environments (Table 4).

Wildlife species struck off-airfield. Among the military rotary-wing strike records where the wildlife strike was reported to have occurred away from an airfield (i.e., off airfield), 37% (172 of 471) contained information regarding the identity of the animal struck. Birds accounted for 97% of the wildlife strikes the occurred off-airfield; bats accounted for the remaining 3% (Table 4).

When only damaging wildlife strikes to military rotary-wing aircraft away from an airfield are considered, 10% (18 of 178) of those reported strike records contained information regarding the identity of the animal struck. Doves and pigeons were the most common wildlife group involved in strikes that resulted in damage to U.S. Air Force rotary-wing aircraft operating off airfield, accounting for 75% of off-airfield damaging strikes. In addition, a collision with a greater mouse-tailed bat (*Rhinopoma microphyllum*), a crested lark (*Galerida cristata*), and a thrush (e.g., unidentified species) resulted in damaged U.S. Air Force rotary-wing aircraft (Table 4).

Discussion

Annual trends in bird strikes to military rotary-wing aircraft followed deployments of U.S. Army and U.S. Air Force rotary-wing flying units related to military missions and combat operations in foreign countries (e.g., Iraq, Afghanistan). For example, increases in wildlife strikes to U.S. Army rotary-wing aircraft during 1991 to 1994 and 2003 to 2009 coincide with Operation Desert Storm and Operation Iraqi Freedom (United Nations Environment Program 2003).

Although wildlife strikes to U.S. Air Force rotary-wing aircraft conducting flight operations during overseas deployments followed a season trend (i.e., strikes were highest in spring and fall), there did not appear to be a strong seasonal trend in wildlife strikes to U.S. Army rotary-wing aircraft. We suspect this might be a result of the distribution of U.S. Army and U.S. Air Force rotary-wing squadrons within in-theater operations. Bird movement patterns within the desert and wetland environments of the Middle East might not be as predictable as migratory movements of birds within and through the various regions and ecotypes of Afghanistan (Ostrowski et al. 2008, Salim et al. 2009, Bedunah et al. 2010, Ararat et al. 2011).

Almost three-quarters of the wildlife strikes to U.S. Army rotary-wing aircraft occurred during the day. If most U.S. Army flight operations occurred during daylight hours, the distribution of wildlife strike events likely was a result of mission timing. In contrast, wildlife strikes to U.S. Air Force rotary-wing aircraft occurred with equal frequency during day and night. This finding is not unexpected, as U.S. Air Force rotary-wing squadrons were likely conducting search and rescue missions during both day and night.

In contrast to studies of civil, fixed-wing aircraft that show most wildlife strikes occur within the airport environment (Dolbeer 2006), we found that more bird strikes occurred during flight operations off-airfield than on-airfield. This is likely due to rotary-wing aircraft spending a greater proportion of flight time off airfield, engaged in terrain flight or traveling en route at heights close to ground level. This finding is consistent with trends associated with bird strikes with civil helicopters (Washburn et al. 2013) and U.S. military aircraft (Washburn et al. 2014) conducting flight operations within the USA. However, the proportion of strikes that were damaging to U.S. Army and U.S. Air Force aircraft was similar between on- and off-airfield wildlife strikes. Although the total number of wildlife strikes that occurred was higher in off-airfield operations, the consequences of a wildlife strike (i.e., damage to the aircraft and the potential for human injury) are important both within airfield environments and during mission flight operations and sorties.

The only reported mammal–aircraft collisions for U.S. Army and U.S. Air Force rotary-wing

aircraft conducting flight operations overseas were with bats (of several species). Similarly, bats accounted for almost all strikes with mammals for civil helicopters (Washburn et al. 2013) and U.S. military aircraft (Washburn et al. 2014) conducting flight operations within the USA. Almost all of the reported bat strikes occurred off airfield, while the rotary-wing aircraft were in terrain flight. Similar to bird strikes, bat strikes can result in significant damage to aircraft (Peurach et al. 2009, Biondi et al. 2013).

Overall, larks, warblers, sparrows, and quail were the wildlife groups that collided with U.S. Air Force aircraft most often during overseas flight missions and combat operations. However, gulls caused the most damage to aircraft operating within airfield environments. During mission flight operations and sorties, doves, pigeons, larks, raptors, and vultures caused the most damage to military aircraft during off-airfield wildlife strike events. During overseas flight operations, U.S. military rotary-wing aircraft conduct activities in a variety of habitat types; consequently, the opportunity exists for strikes to occur with a wide variety of bird species (Behrouzi-Rad 2009, Busuttil and Aye 2009, Salim et al. 2009, Bedunah et al. 2010, Ararat et al. 2011).

Acknowledgments

We thank the U.S. Department of Defense Legacy Resource Management Program for funding and supporting the execution of this project. We appreciate the encouragement, professional advice, and data access provided by the U.S. Air Force Safety Center Bird-Wildlife Aircraft Strike Hazard (BASH) Team (specifically D. Sullivan and Lt. T. Robertson) and the U.S. Army Combat Readiness-Safety Center (specifically R. Dickinson and C. Lyle). This manuscript was prepared under an interagency agreement with the U.S. Department of Agriculture, Animal Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center. The content of this manuscript does not necessarily reflect the views of the Department of Defense Legacy Resource Management Program.

Literature Cited

Ararat, K., O. Fadhil, R. F. Porter, and M. Salim. 2011. Breeding birds in Iraq: important new discoveries. Sandgrouse 33:12–33.

Bedunah, D. J., C. C. Shank, and M. A. Alavi. 2010. Rangelands of Band-e-Amir National Park and Ajar Provisional Wildlife Reserve, Afghanistan. Rangelands 32:41–52.

Behrouzi-Rad, B. 2009. Waterbird populations during dry and wet years in the Hamoun wetlands complex, Iran-Afghanistan border. Podoces 4:88–99.

Biondi, K. M., J. L. Belant, T. L. DeVault, J. A. Martin, and G. Wang. 2013. Bat incidents with U.S. civil aircraft. Acta Chiropterlogica 15:185−192.

Busuttil, S., and R. Aye. 2009. Ornithological surveys in Bamiyan province, Islamic Republic of Afghanistan. Sandgrouse 31:146–159.

Couch, M., and D. Lindell. 2010. Study on rotorcraft safety and survivability. Proceedings of the American Helicopter Society 66:1–12.

DeGraff, R. M., N. G. Tilghman, and S. H. Anderson. 1985. Foraging guilds of North American birds. Environmental Management 9:493–536.

DeVault, T. L., B. F. Blackwell, and J. L. Belant, editors. 2013. Wildlife in airport environments: preventing animal–aircraft collisions through science-based management. Johns Hopkins University Press and The Wildlife Society, Baltimore, Maryland, USA.

Dolbeer, R. A. 2006. Height distribution of birds recorded by collisions with civil aircraft. Journal of Wildlife Management 70:1345−1350.

Dolbeer, R. A., S. E. Wright, J. Weller, and M. J. Begier. 2012. Wildlife strikes to civil aircraftin the United States 1990−2011. U.S. Department of Transportation, Federal AviationAdministration National Wildlife Strike Database, Serial Report Number 18. Washington, D.C., USA.

Dove, C. J., N. C. Rotzel, M. Heacker, and L. A. Weigt. 2008. Using DNA barcodes to identify bird species involved in birdstrikes. Journal of Wildlife Management 72:1231−1236.

Federal Aviation Administration (FAA). 2000. Rotorcraft flying handbook. U.S. Department of Transportation, Federal Aviation Administration, Flight Standards Service, FAA-H-8083-21. Washington, D.C., USA.

Kissling, W. D., C. H. Sekercioglu, and W. Jetz. 2011. Bird dietary guild richness across latitudes, environments, and biogeographic regions. Global Ecology and Biogeography Letters 21:328−340.

Laybourne, R. C., and C. J. Dove. 1994. Prepa-

ration of birdstrike remains for identification. Proceedings of Bird Strike Committee Europe 22:531−534.

Ostrowski, S., A. M. Rajabi, and H. Noori. 2008. Birds and mammals in Dasht-e Nawar, Afghanistan: occurrence and hunting pressure, 2007 surveys. Wildlife Conservation Society, New York, New York, USA.

Peurach, S. C., C. J. Dove, and L. Stepko. 2009. A decade of U.S. Air Force bat strikes. Human–Wildlife Conflicts 3:199−207.

Salim, M., R. Porter, and C. Rubec. 2009. A summary of birds recorded in the marshes of southern Iraq, 2005−2008. BioRisk 3:205−219.

Thorpe, J. 2010. Update on fatalities and destroyed civil aircraft due to bird strikes, with appendix for 2008 and 2009. Proceedings of the International Bird Strike Committee 29:1−9.

United Nations Environment Programme. 2003. Desk study on the environment in Iraq. United Nations Environment Program, Nairobi, Kenya.

U.S. Army. 2012. Fundamentals of flight (FM 3-04.203). Independent Publishers Group, Chicago, Illinois, USA.

Washburn, B. E., P. J. Cisar, and T. L. DeVault. 2013. Wildlife strikes to civil helicopters in the US, 1990−2011. Transportation Research – Part D: Transport and Environment 24:83−88.

Washburn, B. E., P. J. Cisar, and T. L. DeVault. 2014. Wildlife strikes to military rotary-wing aircraft during flight operations within the United States. Wildlife Society Bulletin 38:311−320.

Wielstra, B., T. Boorsma, S. M. Pieterse, and H. H. deLongh. 2011. The use of avian feeding guilds to detect small-scale forest disturbance: a case study in East Kalimantan, Borneo. Forktail 27:55−62.

Zar, J. H. 1996. Biostatistical analysis. Third edition. Prentice-Hall, Upper Saddle River, New Jersey, USA.

Brian E. Washburn is a research biologist for the USDA, Wildlife Services' National Wildlife Research Center field station in Sandusky, Ohio, and is an adjunct assistant professor with Michigan State University, North Carolina State University, and the University of Missouri. He earned his M.S. degree from Pennsylvania State University (wildlife science) and his Ph.D. degree from the University of Kentucky (animal sciences). His research involves finding science-based solutions to wildlife–aviation conflicts, stress and reproductive physiology of wildlife, and habitat management of grassland ecosystems.

Paul J. Cisar is a US Army aviator currently serving as a reservist in the Maryland Army National Guard as the Joint Staff Plans and Training Officer (J5/7). His last active duty assignment was as the Commander of the 1100th Theater Aviation Group assigned to Bagram, Afghanistan. He is employed fulltime as a Department of the Army civil service employee and Chief of Logistics at the US Army Aberdeen Test Center. He earned an A.A. degree in forestry from the University of West Virginia, B.S. degree in wildlife management from the University of Maryland, and an M.S. degree in strategic studies from the U.S. Army War College. His professional interests include understanding and mitigating military aircraft bird strikes.

Travis L. DeVault is the project leader at the USDA, Wildlife Services' National Wildlife Research Center, Ohio Field Station. He earned B.S. and M.S. degrees in biology from Indiana State University and Ph.D. degree in wildlife ecology from Purdue University. His professional interests include understanding and mitigating animal–vehicle collisions, applied ornithology, wildlife food habits and foraging behaviors, and ecosystem services provided by vultures and other scavengers. He is the current chair of the Wildlife Damage Management Working Group of The Wildlife Society.