REPORTING BIAS IN BIRD STRIKES AT JOHN F KENNEDY INTERNATIONAL AIRPORT, NEW YORK, 1979-1998.

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Abstract

Bird-aircraft strike databases have been used to identify, monitor, and manage bird strike problems in the USA nationally and at individual airports. Up to 75% of all bird strikes that occur in the USA may not be reported by pilots or airport control tower personnel. Recent studies have suggested that individual airports may improve their strike reporting rates by having personnel regularly search runways for the remains of birds struck by aircraft. We analyzed a 20-year dataset of runway searches from John F. Kennedy International Airport (JFKIA) in New York to determine the degree of bias in reports of strikes at that airport. At JFKIA from 1979 - 1998, strikes were under-reported by an average of 86.8% ($P < 0.01$), and only 33.9 % ($P < 0.01$) of bird species struck were reported. The addition of unreported strikes to the local strike database also changed the seasonal distribution of strike rates ($P < 0.01$). The local database was essential for evaluating the effectiveness of bird control and habitat management programs at the airport. We recommend the use of runway carcass searches to establish or augment local bird strike databases at airports. Information from these databases should be used to help guide the development and evaluate the effectiveness of wildlife hazard management programs for airports worldwide.

Key Words: Gulls, JFK International Airport, Risk Assessment, Statistics, Strike Reporting, Surveys.

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Introduction

Collisions between birds and aircraft (bird strikes) cost civil aviation in the USA more than $300 million annually and pose a safety risk to flight personnel and passengers (Cleary et al. 1999). Since 1990, bird and other wildlife strikes to civil aircraft in the USA have been reported to the U.S. Federal Aviation Administration (FAA) for inclusion into a National Wildlife Strike Database. Analyses of the 24,000 reported strikes in this database, 1990-1998, has enabled the FAA to characterize wildlife strikes and identify operational conditions that contribute to their occurrence (Cleary et al. 1999, Dolbeer and Wright 1998). However, bird strike reporting is voluntary, and 75-80% of strikes to civil aircraft in the USA may not be reported to the FAA (Dolbeer 1995, Linnell et al. 1999).

By definition, a bird strike is deemed to have occurred when: 1) a pilot reports striking 1 or more birds; 2) aircraft maintenance personnel identify aircraft damage as having been caused by a bird strike; 3) personnel on the ground report seeing an aircraft strike 1 or more birds; or 4) bird remains (carcasses), whether in whole or in part, are found within 61m of a runway centerline, unless another reason for the bird's death is identified (Cleary and Dolbeer 1999). For the purpose of this paper, incidents in categories 1-3 are classified as "reported strikes" whereas carcasses found on runways not associated with a reported strike are classified as "unreported strikes". Depending on the policies of individual airports and air carriers, and the motivation of pilots and ground personnel, these "reported" and "unreported" strikes may or may not be reported to the FAA for inclusion in the national database.

Local databases have also been developed for monitoring and management of strike risk at individual airports (Linnell et al. 1996, 1999). The Port Authority of New York and New Jersey (PANYNJ) has maintained a local database containing reported strikes supplemented with unreported strikes (based on carcass searches) at John F. Kennedy International Airport (JFKIA), New York, since 1979. Using this local bird strike database, PANYNJ personnel found that 80-315 aircraft struck birds annually at JFKIA from 1979-1998 (Dolbeer and Chipman 1999). These strikes have caused millions of dollars in damage to aircraft including at least 65 aborted take-offs and 60 damaged engines and posed a significant threat to human safety (Dolbeer and Chipman 1999).

To mitigate the impact of these bird strikes, JFKIA initiated an active bird management program including vegetation management (Buckley and McCarthy 1994, Barras et al. 2000) and bird-frightening techniques (Marsh et al. 1991) to discourage birds from feeding, drinking, and resting on airport grounds. Because these measures did not prevent birds from flying over the airport (Dolbeer et al. 1989, U.S. Department of Agriculture 1994), the U.S.

Department of Agriculture (USDA), funded by the PANYNJ, implemented an experimental management program at JFKIA in 1991 to reduce strikes by gulls (*Larus* spp.) by shooting gulls attempting to fly over the airport (Dolbeer et al. 1993).

We analyzed reported and unreported bird strikes from the JFKIA bird strike database to test the null hypothesis that there was no difference in 1) the monthly reporting rate, 2) the number and composition of species struck, 3) mean flock size, and 4) mean body mass. We also examined how the annual strike rate has changed for reported and unreported strikes in relation to management actions (gull shooting and tall grass management) at JFKIA.

Methods

We searched the JFKIA Bird Strike Database and extracted all records of reported and unreported strikes at the airport, 1979-1998. We considered carcasses or groups of carcasses found on or near (≤ 61m from the centerline of the runways, Fig. 1) runways during a daily search, not corresponding to a strike reported by a pilot or the airport control tower, to be unreported strikes. Because some strikes are not reported and carcasses of birds involved are never found, we calculated an index of bird strike frequency (indicated strikes), also used by Linnell et al. (1996, 1999), by adding reported strikes to unreported strikes. We compared numbers of reported strikes to the numbers of unreported strikes and indicated strikes during the same time periods to determine strike-reporting rates (Linnell et al. 1996, 1999).

We used all records for which the species was identified to determine which species posed the greatest strike risks among reported and unreported strikes. We also used these data to determine reporting rates for each species, and what factors might affect reporting rates. We compared published mean body mass estimates (Dunning 1993) for species of birds struck at JFKIA to determine the effects of body size on reporting rate. We also determined the mean number of birds struck per incident for each species to gauge the impact of flock size on reporting rate.

Although the database has previously been used for evaluating the effectiveness of the gull shooting program at JFKIA (Dolbeer and Chipman 1999), we used reported and indicated strikes involving laughing gulls (*Larus atricilla*) and other birds to determine the effectiveness of the database for monitoring changes in strike risk over time, and to determine which groups of birds pose an increasing risk of strikes in the future.

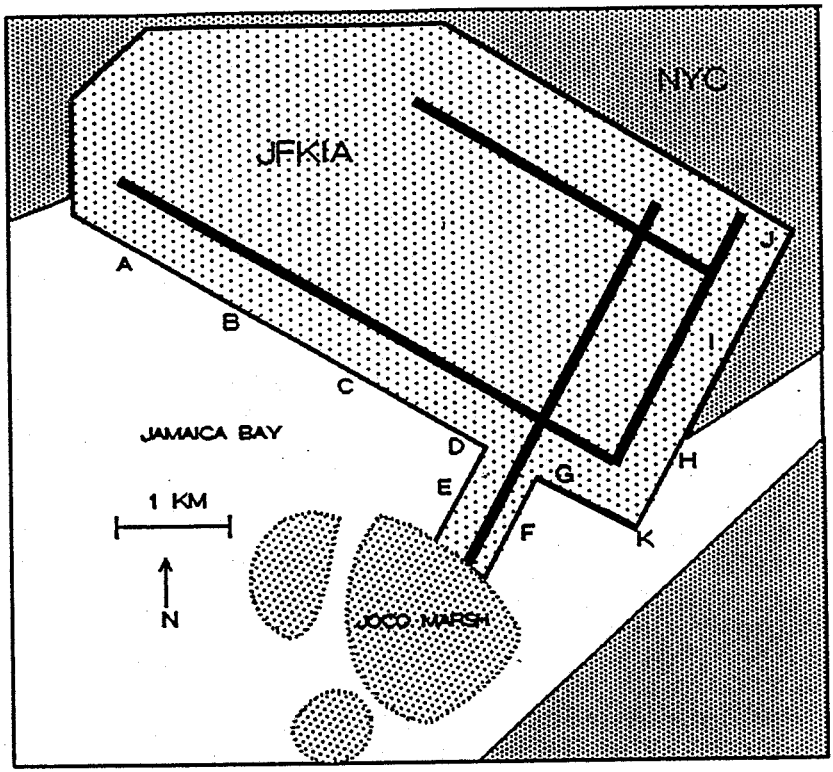

Figure 1. Schematic showing runway configuration at John F. Kennedy International Airport, New York, and proximity of the airport to JoCo marsh where a nesting colony of laughing gulls has resided since 1979.

We used SAS statistical software (SAS 1990, Cody and Smith 1991) to calculate descriptive statistics, conduct simple correlations, and perform simple linear regression to help characterize the magnitude and temporal trends in wildlife strikes at JFKIA. Differences were declared significant at alpha = 0.05.

Results

General strike characteristics

Only 462 of 3,484 bird strikes were reported by aircraft operators at JFKIA, 1979-1998 (Fig. 2). Annual percent of total strikes that were reported ranged

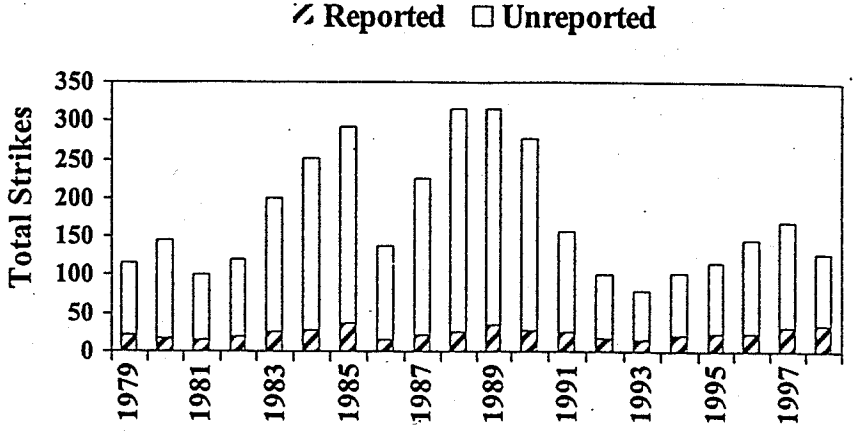

Figure 2. Number of reported and unreported bird strikes per year at John F. Kennedy International Airport, New York, 1979-1998.

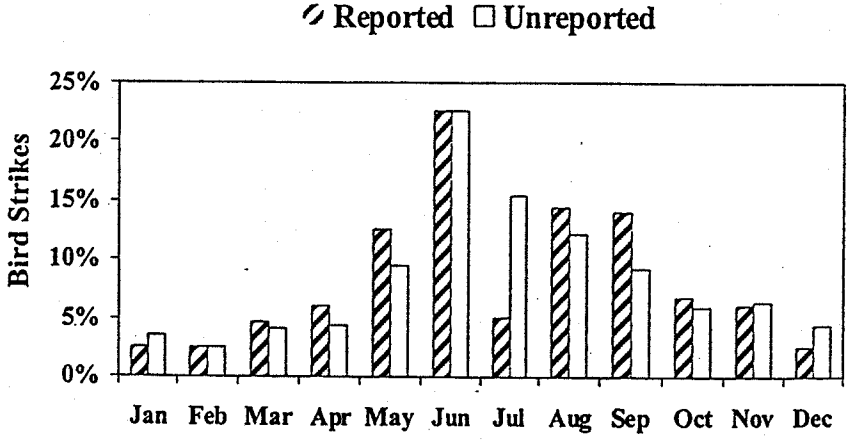

Figure 3. Percent of reported and unreported bird strikes occurring by month at John F. Kennedy International Airport, New York, 1979-1998 (n=462 reported strikes, 3022 unreported strikes).

from 8.0 - 21.4% (□ = 13.3%, n = 20, SD = 4.08). Strike frequency peaked during summer, with the greatest proportion (22.6%) of strikes occurring in June and the fewest (2.6%) strikes occurring in February (Fig. 3). Seventy-two species were involved in strikes at JFKIA 1979-1998, and 14-36 (□ = 20.8, n = 20, SD = 5.97) species were struck each year. By using runway searches, species was determined for 91.6% (3,192 of 3,484) of all indicated strikes. Of 3194 strikes for which species was known, most common species groups were gulls (71.5%, 2281) and raptors (10.7%, 342). A comprehensive list of species involved in strikes at JFKIA is presented in Appendix 1. Aircraft movement volume was relatively constant (Dolbeer and Chipman 1999).

Characteristics of reported and unreported strikes

Indicated strikes provided a more complete identification of the species using the airspace over JFKIA than did reported strikes. On average, only 33.9% (11.1 - 61.1%, 1979-1998) of the total species struck at JFKIA were reported struck each year.

Bird size did not appear to affect reporting rates (t = 0.32, df = 1, 313, P = 0.75), as evidenced by the lack of a difference in mean body mass between reported (□ = 697g, n = 285, SD = 731) and unreported (□ = 711g, n = 2909, SD = 523) bird strikes, and the lack of correlation between mean bird mass and proportion of strikes to that species reported (r = -0.16, P = 0.18). However, strikes involving flocks of birds appeared more likely to be reported than did those to individual birds. The mean number of birds involved in a reported strike (□ = 4.01, n = 285, SD = 13.44) was greater (t = -3.60, df = 1, 287, P < 0.01) than for unreported strikes (□ = 1.13, n = 2909, SD = 3.12). Also, the mean number of birds struck for each species was correlated with proportion of strikes to that species reported (r = 0.53, P < 0.01). Ninety percent of unreported strikes involved a single bird, whereas 65% of reported strikes involved multiple birds.

The seasonal timing of reported versus non-reported strikes also differed (X^2 = 96.74, df = 11, P < 0.01). The major difference occurred in July, when reported strikes were under-reported relative to unreported strikes (Fig. 2).

Use of unreported and reported strike data to evaluate management activities

Prior to the gull shooting program at JFKIA beginning in 1991, nesting effort by laughing gulls increased from 15 to 7629 nests (>500%), 1979-1990 (Dolbeer and Chipman 1999). Laughing gull nesting effort was a significant predictor of reported, unreported, and indicated laughing gull strikes (P < 0.01). However, indicated strikes were better correlated with nesting effort (94.0%) than reported and unreported strikes (93.6 versus 86.4%).

The annual number of indicated laughing gull strikes increased from 2 to 135 (t = 8.20; df = 1, 11; P < 0.01) prior to the shooting program, 1979-1990. Although reported laughing gull strikes also increased (t = 5.77; df = 1, 11; P < 0.01; Fig. 4) from 1979 -1990, the magnitude of the increase was < 10% of indicated laughing gull strikes, with none reported until 1981, and annual strike frequency ranging from 0 to 11, 1981-1990. Numbers of indicated laughing gull, other gull, and total gull strikes decreased 20 - 65% from their peak years (1988-1990) after shooting began in 1991, then remained relatively constant (-2.06 < t < -0.95; df = 1, 7; - 0.08 < P < 0.38). Using reported strikes alone, the same trends were evident (-1.38 < t < 1.31; df = 1, 7; 0.22 < P < 0.49). However, reported and indicated strikes to other birds increased during the same time period by 131% and 93%, respectively (P = 0.01 for both).

Indicated strikes to birds other than gulls increased by 122% from 37 in 1986, when a tall-grass vegetation management program began at JFKIA to 82 in 1998 (t = 4.58; df = 1, 12; P < 0.01). More strikes by non-gull birds than by gulls have occurred annually since 1996 (Fig. 5). Reported strikes to birds other than gulls also increased during the same time period (t = 7.87; df = 1, 12; P < 0.01). Although reported and indicated strikes were strongly correlated (r = 0.85, P < 0.01), only 8 - 37% of indicated strikes to non-gull birds were reported during this time period.

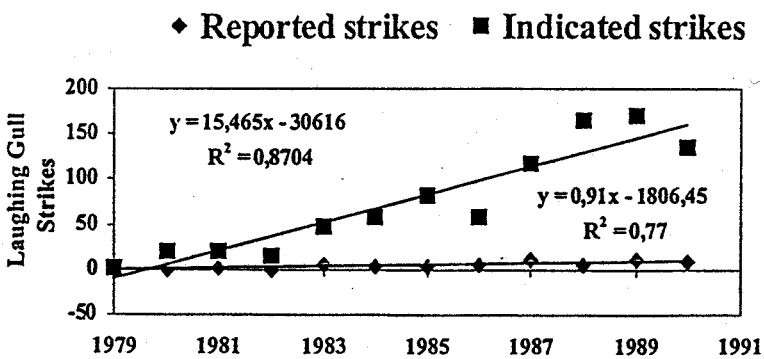

Figure 4. Increases in reported and indicated (reported + unreported) bird strikes prior to the gull shooting program at John F. Kennedy International Airport, New York, 1979-1990.

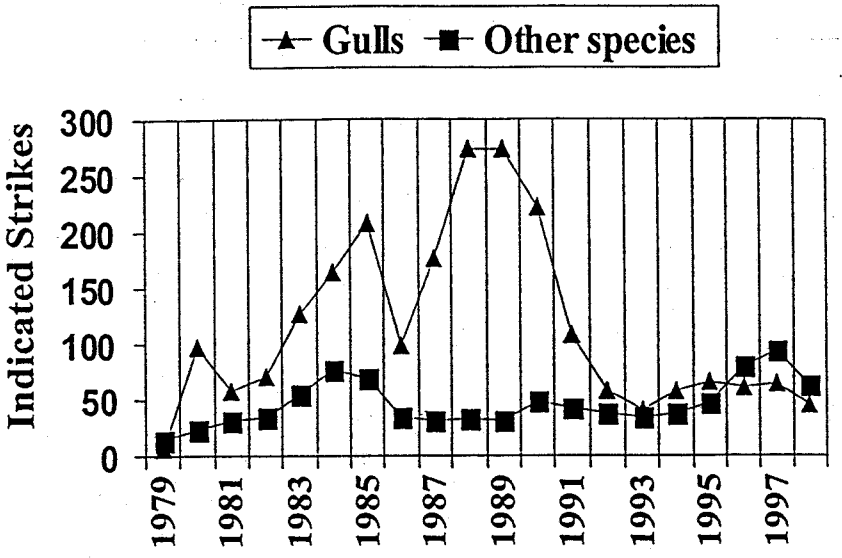

Figure 5. Annual number of indicated (reported + unreported) bird strikes involving gulls and other bird species at John F. Kennedy International Airport, New York, 1979-1998

Discussion

Reporting bias

Reported bird strike characteristics at JFKIA, 1979-1998, generally were not representative of data collected from runway carcass searches. As noted in previous studies at this airport (Burger 1985) and other airports (Linnell et al. 1996, 1999), strike reports underestimated the number of indicated strikes and the number of species involved, overestimated the number of individuals involved per strike, and portrayed a different pattern of the seasonal timing of strikes than was indicated by the abundance and species composition of carcasses found on or near the runways. In cases where reported strikes were useful for monitoring a general trend, such as the increase in laughing gull strikes and nesting effort prior to 1991, the magnitude of the problem was underestimated when strike reports alone were used. Therefore, we support the recommendation by Linnell et al. (1999) to use carcass searches to supplement pilot reports and provide airport managers with less biased data to aid strike risk monitoring and management efforts.

The exact cause of death for each carcass found on or near a runway cannot usually be confirmed as a collision between a bird and a moving aircraft, even if major trauma is evident. Specific causes of wildlife mortality are often difficult to determine, and require a thorough necropsy (Roffe et al. 1994, Lyne et al. 1998). We argue, instead, that whether a bird is killed by collision with an aircraft or by a vortex or jet blast from a near miss is irrelevant. The fact that a carcass was found on or next to an active runway confirms that the individual or flock shared the airspace with aircraft and thus posed a strike risk. Thus, the information gained from carcass counts is a reliable indicator of the species-specific frequency of bird-aircraft interactions. Combined with data from airport bird surveys (Cleary and Dolbeer 1999), a more comprehensive picture of bird activity and strike risk for a particular airport may be obtained.

Reported strikes, combined with carcass data, provide an essential response variable for evaluating the effectiveness of management programs targeted at reducing the use of airports by specific species or groups of species. As Burger (1985) and others (Buurma et al. 1989, Dolbeer 1998, Dolbeer and Chipman 1999) observed in previous studies, bird strike trends and frequency at JFKIA 1979-1998 appeared to be driven by gull activity and abundance over the airport, especially before the gull shooting program was initiated in 1991. Likewise, Linnell et al. (1996, 1999) found that most strikes at Lihue Airport, Hawaii, were attributed to a few species of primary concern. Reductions in bird strikes since 1991 at JFKIA indicate that the USDA shooting program has been effective and species specific, reducing strikes to gulls, despite the continued viability of the adjacent laughing gull nesting colony (Dolbeer and Chipman 1999) and continued increases in strikes to other birds.

Conversely, strikes to other birds increased since 1986 despite the implementation of a tallgrass vegetation management strategy, generally thought to reduce bird use of the airport habitats (Brough 1971, Mead and Carter 1973, Brough and Bridgman 1980, Dekker and van der Zee 1996). Strike monitoring using local indicated strike data and determinations of which species posed greatest risks of bird strike at JFKIA led to more detailed vegetation management studies at the airport and to adjustments in the implementation of the tallgrass management strategy (Barras 2000). Although increases in reported strikes to birds other than gulls were detected in the same time period, the magnitude of the increase without the unreported strikes obtained from carcass searches may not have been sufficient to cause a management response.

Management and research needs

We recommend daily runway searches for carcasses of birds and other wildlife that may have been struck or interacted with aircraft at any airport with wildlife strike problems. These data should be combined with reported strikes to build and maintain local wildlife strike databases. These data should also be reported to a central location for inclusion in a national database (e.g., Cleary et al. 1999). Regular analyses of these local databases should be used to continually monitor and characterize strike problems, and evaluate the effectiveness of airport wildlife management activities. Further research into the factors that affect reporting rates is needed to help reduce bias in national wildlife strike databases for which representative data needed to better estimate and reduce reporting bias do not exist.

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Appendix 1. Number of birds of known species (American Ornithologists Union (AOU) Common names, AOU 1998) struck by aircraft at John F. Kennedy International Airport, New York, 1979-1998.

Species	Reported	Not reported	Total strikes	Proportion reported
American black duck	1	32	33	0.03
American coot	0	2	2	0
American crow	2	15	17	0.12
American kestrel	6	70	76	0.08
American oystercatcher	1	26	27	0.04
American robin	0	2	2	0
Barred owl	0	1	1	0
Barn swallow	1	1	2	0.5
Black-billed magpie	0	1	1	0
Black bellied plover	0	8	8	0
Black-crowned night-heron	1	37	38	0.03
Black skimmer	0	12	12	0
Brant	3	11	14	0.21
Brown thrasher	0	1	1	0
Bufflehead	0	1	1	0
Burrowing owl	0	1	1	0
Canada goose	9	18	27	0.33
Canvasback	0	1	1	0
Cattle egret	0	64	64	0
Common barn-owl	4	134	138	0.03
Common loon	0	1	1	0
Common moorhen	0	1	1	0
Common nighthawk	0	1	1	0
Common tern	1	19	20	0.05
Double-crested cormorant	2	10	12	0.17
Dunlin	1	0	1	1
Eastern Meadowlark	0	1	1	0
European starling	13	11	24	0.54
Gadwall	1	0	1	1
Glossy ibis	0	3	3	0
Great black-backed gull	23	164	187	0.12
Great blue heron	0	7	7	0
Great egret	1	7	8	0.12

Appendix 1 (Continued)

Species	Reported	Not reported	Total strikes	Proportion reported
Green-backed heron	0	1	1	0
Greater scaup	0	3	3	0
Green-winged teal	0	1	1	0
Herring gull	56	773	829	0.07
Horned lark	4	1	5	0.80
Killdeer	1	6	7	0.14
Laughing gull	78	1050	1128	0.07
Lesser golden-plover	3	8	11	0.27
Least sandpiper	0	1	1	0
Least tern	0	2	2	0
Long-eared Owl	0	3	3	0
Mallard	2	57	59	0.03
Merlin	0	5	5	0
Mourning dove	10	14	24	0.42
Northern flicker	0	7	7	0
Northern harrier	4	24	28	0.14
Northern shoveler	0	1	1	0
Osprey	3	14	17	0.18
Peregrine falcon	4	12	16	0.25
Red-necked grebe	0	1	1	0
Red-necked phalarope	2	11	13	0.15
Red-tailed hawk	0	3	3	0
Red-winged blackbird	1	0	1	1
Ring-billed gull	4	133	137	0.03
Rock dove	15	25	40	0.38
Rough-legged hawk	0	3	3	0
Semi-palmated plover	1	3	4	0.25
Semi-palmated sandpiper	1	1	2	0.25
Short-eared owl	3	38	41	0.07
Snow bunting	13	3	16	0.81
Snowy egret	0	2	2	0
Snowy owl	0	15	15	0
Tree swallow	8	12	20	0.4
Upland sandpiper	0	1	1	0
Whimbrel	0	1	1	0
Willet	0	3	3	0
Wood duck	0	1	1	0