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Lightning Accidents In Uganda

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***Abstract*— This paper addresses the lightning safety environment in Uganda that requires urgent and serious attention of the international expert community. We present recent statistics of reported lightning incidents in Uganda which show that the number of injuries and deaths are overwhelmingly high during year 2011 thus the situation can be declared critical. During the five-year period from January 2007 to December 2011, there were 91 reported lightning accidents which accounted for a total number of 150 deaths and 584 cases of personal injuries to which the victims did not succumb. Out of 150 deaths 95 reported in 2011. The actual number in each case may be much higher as many deaths and injuries go unnoticed due to lack of communication between rural communities and government authorities or media sources. The detailed analysis of several incidents reveals that injuries and deaths are basically due to both lack of awareness and absence of proper protection and safety schemes. The decisive factors of the ill-effects of incidents are time of the day, month of the year, part of the country, location of the incident etc. Most of the accidents have occurred either in the afternoon or in the evening. A spread of incidents can be seen throughout the six month period from June to November with June as the month of highest reported deaths. The highest number of incidents has been reported in the Northern Province of the country. Interestingly, the highest number of incidents, deaths and injuries has occurred while the victims were inside permanent structures. After analyzing these incidents a stepwise procedure is proposed to curb such incidents in the future.**

Keywords-lightning injury; Uganda; step potential; direct strikes; safety scheme

I. INTRODUCTION

Global lightning occurrence maps, based on satellite data, show that many parts of African continent records the highest lightning densities. However, until recent decades, the international community hardly received information on the severity of lightning accidents in the Dark Continent. The first major lightning accident in Africa was reported in 1998, where all 11 players of a single football team were killed by lightning in the Eastern Province of Kasai in Democratic Republic of Congo (World: Africa Lightning kills football team, BBC News, 28th October 1998). The original news report (L'Avenir/Kinshasa) stated that more than 30 spectators have received severe burns whereas the players of the other team who were in the field with the victims came unscathed. This peculiar incident is yet to be investigated with a scientific view point as the region of incident is hardly reachable due to civil unrest in Congo.

Many other disturbing reports on lightning incidents in Africa have been published since the Congo incidents. Few such major accidents reported only during year 2010/2011 are given below.

25 people being killed during one month period in June/July 2011 in Tigray, South West region of Ethiopia ("Lightning kills 25 amid extensive drought in East Africa", Sudan Tribune, 27th July 2011);

- 20 people in Kenya were killed by lightning within one week in June/July 2011 which include all 8 members of a family who were affected by a single strike ("Kenyans Alarmed as Lightning kills 20 people within one week", Julalo, 05th July 2011);
- 15 people were killed by lightning during one weekend in January 2011 in KwaZulu-Natal, South Africa ("South African politician says number of lightning deaths is rising", The Guardian, 04th January 2011);
- Seven school children between the ages of 10 and 13 were killed when lightning struck the thatched roofed structure where they were attending a Quranic school in the remote village of Sarguilla in southern Darfur, Sudan ("Lightning kills 7 school children in Darfur", Gulf News, 17th August 2010);
- Nineteen people were killed within a single day in Gombe, Yobe and Bauchi states in Nigeria ("Lightning Kills 19 in Gombe, Yobe, Bauchi - Man Loses Two Wives, Two Children", Vanguard, 29th June 2011);
- Three children were killed and 10 people were injured when lightning struck a an outdoor gathering in Bigogwe sector in Nyabihu District, Rwanda ("Lightning Kills Three Children", The New Times, 28 June 2011)

The above examples show that the risk of death or injury due to lightning in many African nations is either in par with or greater than that in several South Asian regions as it has been reported in [1]. However, none of these incidents have been investigated in depth to make conclusions regarding the injury mechanism, accident locations, level of exposure of the victims etc.

Interestingly, the first ever scientific documentation on lightning fatalities is done in Africa by a scientist who lived in

Egyptian Equatorial Province in the second half of 19th Century [2]. However, since then not much work has been done with regard to this subject except for few research papers published on fatalities in South Africa [3, 4] and a couple of very recent publications regarding the accidents in Zambia and Nigeria [5, 6]. Few papers have also been published regarding the lightning scenario in Kenya [7, 8]. The work presented in [9], provides several animal deaths and injuries in African continent as well. Despite the small number of scientific work on lightning effects in Africa, during the recent years, a large number of lightning incidents have been reported from several African countries, such as Uganda, Rwanda, Nigeria, Chad, Congo and Zambia etc.

Investigation that has been conducted in Bangladesh, Sri Lanka and USA [10, 11] shows that causes of exposure of human beings to lightning effects have both similarities and differences based on the region. However, we assume that in many parts of Africa the level of awareness, socio-economic standards, indigenous beliefs and attitudes towards lightning victims and sense of social responsibilities are similar. Hence, we presume that by investigating incidents of one country in the region, reasonable conclusions can be drawn on the level of threat, accident environment and precautionary measures to be taken to curb the number of accidents etc. for the whole region.

In the above backdrop, we have done in-depth study on the lightning accidents reported during the recent past in Uganda, a country that is labeled as having one of the worst lightning related incidents at present. Irrespective of the prevailing pathetic situation no serious action has been taken either by local scientific community or international experts to address the lightning safety issues in the country.

The incidents analyzed in this paper are collected during a 5-year period from January-2007 to December 2011. Uganda is a landlocked country bordered on the east by Kenya, on the north by South Sudan, on the west by the Democratic Republic of the Congo, on the southwest by Rwanda, and on the south by Tanzania (Fig. 1). The southern part of the country includes a substantial portion of Lake Victoria, which is also shared by Kenya and Tanzania. The country is situated between latitudes 4°N and 2°S (a small area belongs to North of 4°), and longitudes 29° and 35°E. Irrespective of its equatorial location, Uganda has a mild temperature profile due to it high elevation. Most parts of the country are on a plateau of altitude around 1000 m. As per the information issued by Department of Meteorology, Uganda; the country experiences rainy season basically from March to May. Light scattered showers are common during November and December. In general, the country passes through dry climate from December to February and June to August. The maximum temperature ranges between 18° to 28° C depending on the region.

As per the global lightning density maps issued by NASA under NASA based on the observations through of the NASA OTD (4/95-3/00) and LIS (1/98-2/3) instruments, Uganda has a lightning density of 10-15 flashes /km^2/year^{-1}.

As one of the pioneering studies on lightning accidents in Africa we expect that findings of the investigation presented in this paper will open the eyes of experts in the field to take proper actions in safeguarding the people of the African Continent against the ever increasing lightning threats.

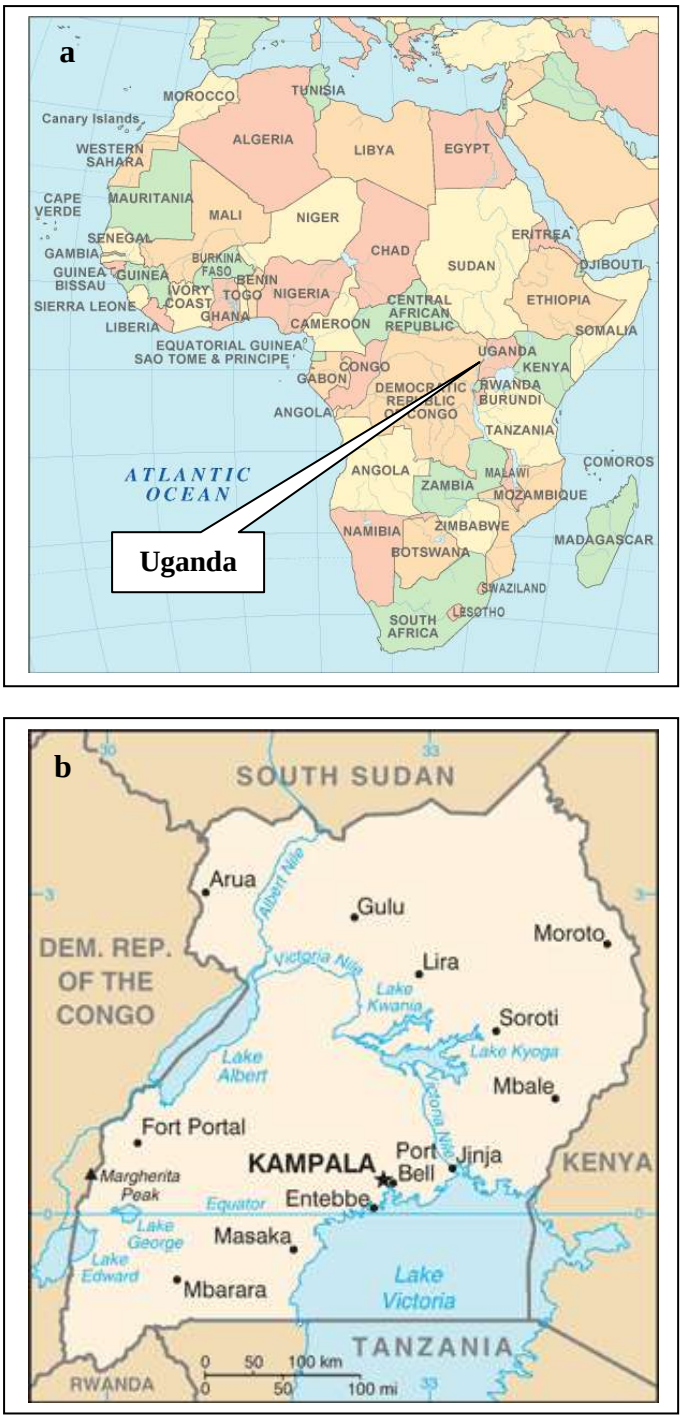

Figure 1. a. Location of Uganda in the African continent.
b. Detailed map of Uganda

II. METHODOLOGY

Data on the lightning incidents have been collected from all parts of the country without giving preferences to any specific region in gathering information. The sources of information were news agencies, personal communications, reports found at Meteorological department of Uganda and site visits. The validity of information has been cross-checked from multi-sources.

Site visits were made by an expert team to the places within reach and data have been collected and verified through site inspections, formal and informal interviews and records available at local authorities. Note that sites for visits have been selected on the basis of convenience and accessibility.

III. RESULTS

The summary of the information on province-based lightning accidents in Uganda has been given in Table-I. Fig. 2 to Fig. 6 provide bar charts of occurrence distribution with year (from 2007-2011) and month, part of the day, location of the accident and province of the country. Each variable in the *x*-axis is divided to three categories; total number of incidents, number of deaths and number of injuries. Note that an "incident" is referred to an event of lightning strike, hence in a single incident there can be multiple deaths and injuries. "Injuries" are referred to lightning victims that do not succumb to their injuries. Hence the number of deaths is not a subset of the number of injuries.

It is clearly seen in Fig. 2 that number of incidents, injuries and deaths due to lightning in Uganda have been increased markedly during the year 2011. All four provinces show this uncharacteristic high occurrence of lightning accidents in 2011. With respect to the average annual numbers during the four year period from 2007 to 2010, incidents, deaths and injuries are approximately 770%, 700% and 2500% respectively higher in 2011. Even when the cumulative values of the three parameters from 2007 to 2010 are taken into account, those in 2011 are greater by approximately 200%, 170% and 620% respectively. It will take some time to figure out the reasons for the drastic increment in lightning accidents in 2011. However, this will be an extremely alarmism trend if it continues in 2012 and onwards as well.

The lightning accidents in Uganda peak in June and maintain a rather high value until November (Fig. 3). Interestingly the number of lightning accidents has a very low value in April, the month known for short duration showers that accompany thunderstorms. In general, according to the five year data on the distribution of lightning accidents (not lightning occurrence density), the year can be divided in to two halves; a high accident period from June to November and a low accident period from December to May.

The time segmentation given in Fig. 4 is done on the basis of 6 hours per each segment starting at 6 am (morning). The highest number of accidents occurs in the afternoon (12 noon to 6 pm), a fact that is in agreement with observations done in South Asia [10]. In many countries where lightning occurs predominately due to convective thunderstorms, most of the cumulonimbus clouds mature in the afternoon, hence understandably the peak period of lightning occurrence and that of accident occurrence coincide.

Fig. 5 shows that an overwhelming large number of accidents have been occurred while the victims are inside permanent buildings. It should be noted that the number of injury to number of death ratio in the case of "inside permanent buildings" is 6.4. The same ratio for the cases of "inside temporary buildings, "outside open space" and "outside under a tree" is 2.1, 3.0 and 1.9 respectively. This shows that the chances of survival after being affected by lightning are quite high if an incident occurs while the victim is inside a permanent structure.

Out of the four provinces in the country, the Northern Province tops in the list of lightning accidents (Fig. 6). It is followed by the Western, Central and eastern provinces respectively. The reason for the distribution of the lightning accidents in the above manner is difficult to be explained with presently available information..

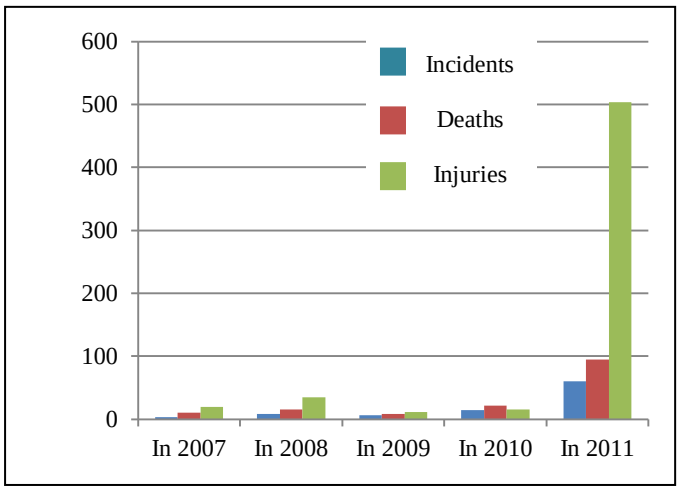

Figure 2. Lightning occurrences based on year

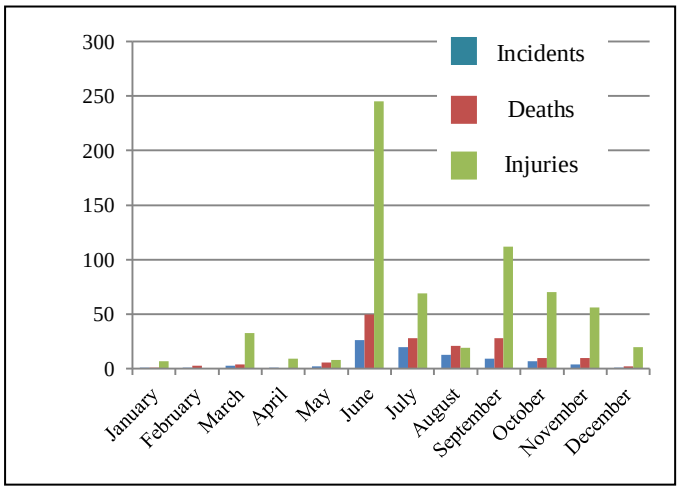

Figure 3. Lightning occurrences based on month of the year

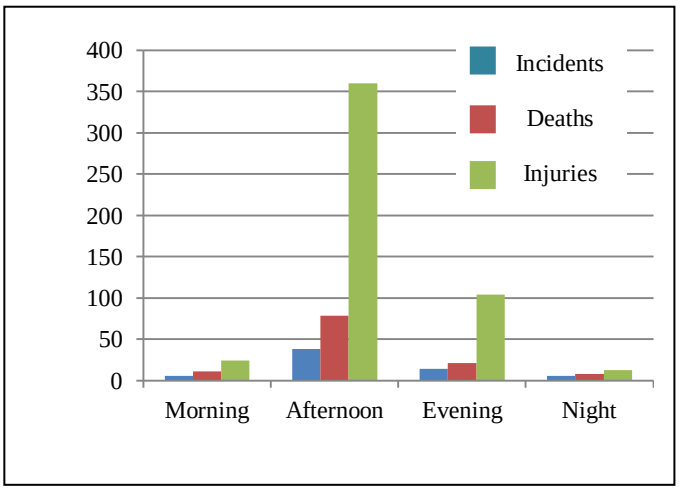

Figure 4. Lightning occurrences based on the time of the day

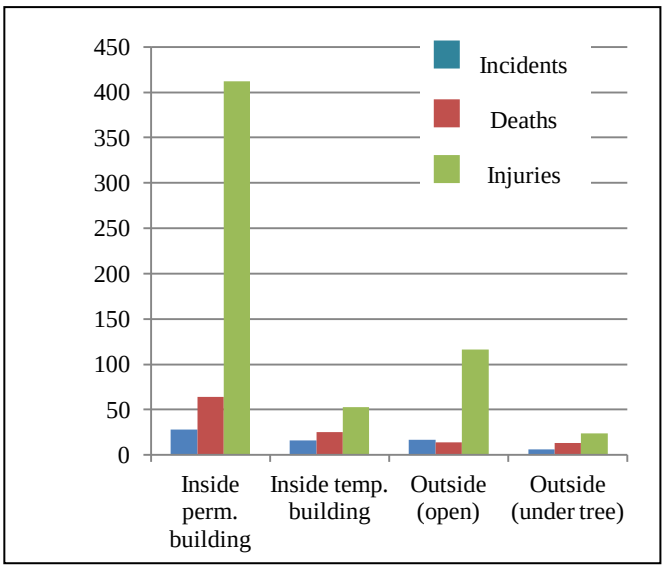

Figure 5. Lightning occurrences based on the location of the accident

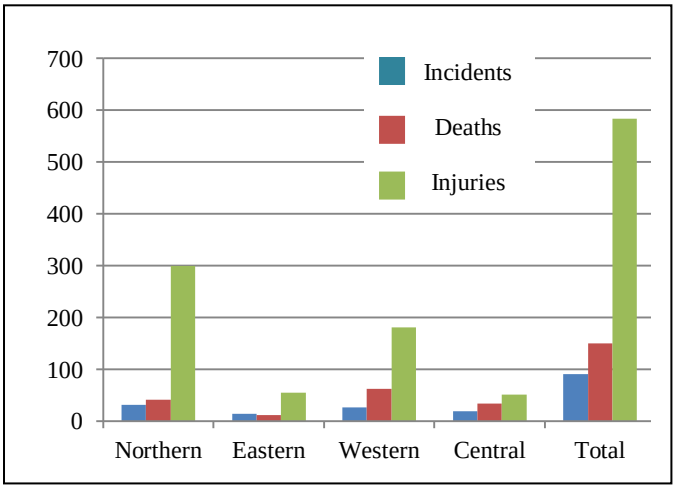

Figure 6. Lightning occurrences based on province

IV. Discussion

The most unexpected outcome of this study is the place of occurrence of the lightning accidents (Fig. 4). In contrast to the wide agreement that lightning accidents are highly probable in temporary structures and outdoors, the highest number of lightning accidents have taken place while the victims were taking shelter in permanent structures. This seemingly confusing observation can be well explained by investigating the house structures in Uganda. Most of the so called "permanent houses" in rural Uganda are brick, clay or wooden structures with thatch or iron sheet roofs. Almost all of these houses are not given any type of structural protection against lightning. Fig. 7 shows a typical structure in most African countries, which is treated as a permanent house. As the number of these type of houses are overwhelmingly large compared to temporary structures, the probability of finding a lightning victim in such "permanent" structure may be quite high. As one can easily figure out the risk of lightning injury for a person inside such house is the same as someone seeking shelter in a temporary structure.

One of the most terrible lightning incidents that has ever reported in the world is the death of 18 school pupils and their teacher on the 28th June 2011 in Kiryandongo district, about 225 km northwest of Kampala. The event took place in the afternoon while the victims were inside a classroom. The single lightning strike to the building killed 19 people while injuring about 50 others. The lightning that struck the unprotected school building left a large hole in the roof. The reports of the incident show that the victims may have subjected to side flashes of the lightning that is attached to the roof. However, possibilities of upward leaders and step potential cannot be discarded.

Figure 7. A typical rural house in Africa that is considered as a permanent building

Incidents where large number of school students was affected by lightning while they were schooling are common in Uganda. However, number of such incidents recorded in 2011 was unparalleled. Many survivors, who are in their teen ages, showed long term symptoms after the incidents. As per the clinical reports survivors suffer from Psychological trauma, and partial paralysis in their bodies. Many of them complain of chest pain, stomach complications, talking and breathing deficiencies and loss of memory.

It is noteworthy to mention that the incident in Kiryandongo district and several other accidents where large number of people have been affected by single lightning have been occurred in June a month classified as belong to dry season. In most of the countries with tropical monsoonal climate, such as Sri Lanka and India, peak lightning seasons are observed in inter-monsoonal periods during which rainfall is considerably less than that during monsoons [11, 12]. In most tropical climates, where lightning is brought by convective type thunderclouds, such observation is envisaged. On the other hand an occasional lightning in the dry season may bring heavy casualty as the high soil resistivity during the dry season may considerably increase the step potential hazards. In summary it may be noted that the distribution of lightning density may not follow the rainfall distribution and also the distribution of lightning density may not follow the lightning accident distribution.

In contrast to the lightning protection schemes planned for other countries [12], in Uganda, awareness promotion alone will not make any viable improvement in the public lightning safety. One of the major guideline of lightning safety; "seeking shelter in a sturdily built structure under thunderstorm conditions", is not practical in many parts of rural Africa as there may be no such structure within accessible proximity in need.

Therefore a prime requirement for such regions is to give total lightning protection to at least one building in a given community so that all can gather inside during thunderstorm period. Places of mass gathering such as schools, hospitals, supermarkets, government office complexes, religious places etc. should compulsorily be safeguarded by a lightning protection system designed and implemented according to a well accepted standard or guideline.

However, gathering into a protected structure specifically for lightning safety may not be possible under certain circumstances, especially at the dead of the night. Therefore a more viable solution is to provide low-cost lightning protection system to individual structures. Such schemes are proposed in [13]. For many communities in rural areas even such low-cost solutions may be unaffordable. Therefore government intervention in installing lightning protection schemes is very vital.

To curb down ever rising number of lightning victims, the implementation of structural protection system should be augmented by launching awareness programs to educate public on lightning safety. Public awareness can be enhanced effectively in many developing countries by educating the school children [12]. Such awareness programs have successfully been conducted in South Asia, a region ridden by poverty and low rate of literacy [11]. The message of lightning safety may also be conveyed to the public through, local authorities, police, welfare workers and community leaders. We propose following modes to enhance public awareness.

a. Poster and banner campaigns
b. Distribution of leaflets, booklets and other reading materials among urban communities
c. Short documentary films or TV clips
d. Speeches, presentations and educational programs at higher societal layers
e. Stage dramas and storytelling at religious congregations and community gatherings
f. Door to door visiting by an expert panel
g. Workshops and conferences at the high ends (political and social leadership, funding agencies and policy makers).

V. CONCLUSIONS

Five years of lightning accident records reveal that lightning related victims in Uganda has a dramatic rise in 2011. June is the month that has the highest number of lightning victims. The six-month period from June to November can be labeled as a high lightning accident period while the six months from December to May can be treated as a low lightning accident period. Most of the lightning accidents have been reported during the afternoon. Northern Province of Uganda records the highest number of lightning accidents during the period of data collection.

We propose a comprehensive safety scheme; structural protection systems augmented by safety awareness programs to curb the lightning accidents in Uganda, which have been increasing at an alarming rate.

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Table I: Lightning related incidents investigated

	No of incidents					No of deaths					No of injuries				
	N	E	W	C	Total	N	E	W	C	Total	N	E	W	C	Total
Morning	1	0	0	5	6	1	0	0	10	11	4	0	0	20	24
Afternoon	6	7	13	12	38	5	8	42	24	79	109	25	187	39	360
Evening	4	1	9	0	14	8	0	13	0	21	30	11	63	0	104
Night	6	0	0	0	6	8	0	0	0	8	13	0	0	0	13
Inside perm. building	7	6	9	8	28	7	7	35	15	64	194	32	158	28	412
Inside temp. building	8	0	6	2	16	10	0	9	6	25	19	0	31	3	53
Outside (open)	5	5	4	3	17	5	2	4	3	14	39	20	44	17	116
Outside (under tree)	1	1	2	2	6	3	1	5	4	13	15	1	0	8	24
January	0	0	1	0	1	0	0	1	0	1	0	0	7	0	7
February	0	0	1	0	1	0	0	3	0	3	0	0	0	0	0
March	2	0	1	0	3	3	0	1	0	4	29	0	4	0	33
April	0	1	0	0	1	0	0	0	0	0	0	9	0	0	9
May	0	1	0	1	2	0	3	0	3	6	0	8	0	0	8
June	11	5	4	6	26	15	2	23	10	50	131	18	71	25	245
July	3	5	8	4	20	1	4	15	8	28	15	15	23	14	69
August	4	2	2	5	13	7	3	2	9	21	8	5	3	3	19
September	4	0	4	1	9	8	0	10	0	28	59	0	44	9	112
October	4	0	2	1	7	7	0	2	1	10	57	0	12	1	70
November	0	0	2	2	4	0	0	3	7	10	0	0	48	8	56
December	0	0	1	0	1	0	0	2	0	2	0	0	20	0	20
In 2007	1	1	1	0	3	2	1	7	0	10	1	5	14	0	20
In 2008	3	1	1	3	8	5	2	3	5	15	33	0	0	2	35
In 2009	3	0	1	1	6	5	0	2	1	8	3	0	0	8	11
In 2010	5	1	8	0	14	11	0	11	0	22	3	9	6	0	15
In 2011	19	11	15	15	60	19	9	39	28	95	260	41	161	41	503