

**AUTOMATIC BAT COUNTING AND IDENTIFICATION OF BAT SPECIES
USING TERRESTRIAL LASER SCANNING**

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DEDICATION

Family that always believe in me

Noor Azmy Bin Zainaabidin

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Suhana Iryani Binti Noor Azmy

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ABSTRACT

The current practice in roosting bat population survey and species identification is either based on net capture, visual observation or optical-mechanical count methods. However, these methods are intrusive, tedious, time consuming and at best, only reports an estimation of the roosting population of bats. Here, the present study showed the use of Light Detection and Ranging (LIDAR) concept using terrestrial laser scanner was successful in remotely identifying and determining the exact population of roosting bats in caves. The laser scans accurately captured the three dimensional (3D) features of the roosting bats and their spatial distribution pattern in total darkness. Using LIDAR, the determination number of bats can be conducted, spatially analyze the 3D distribution of bat populations as well as generate a 3D topological structure of the roosting cave. This resulted in a high resolution model of the cave, enabling exact count of visibly differentiated individual bats. This successfully leads to the species identification of the *Hipposideros larvatus* and *Hipposideros armiger* reported in this study. This studies anticipate that the development of the LIDAR into a non-intrusive technique will open up new possibilities in bat roosting studies. This novel method would possibly allow future works accomplishment of researchers to study roosting behavior such as maternity roosting patterns, roost sharing and roost-switching patterns within the topographical context of the speleological (caves, subterranean spaces and caverns) internal surface, thus making rigorous quantitative characterizations of cave roosting behavior possible. The final results of this study would be an automated procedure for bat population count and the function of point cloud data in assisting the species identification.

Keywords: Laser Scanning, Roosting Bats, LIDAR, Automatic Bat Counting, Bat Population.

ABSTRAK

Kaedah praktikal yang biasanya digunakan di dalam kajian bilangan populasi kelawar serta pengenalpastian spesies adalah menerusi penangkapan kelawar menggunakan jaring (*net capture*), pemerhatian visual ataupun pengiraan menggunakan peralatan optikal-mekanikal. Bagaimanapun, kaedah-kaedah ini berbentuk *intrusive*, yang mana ia mengganggu subjek secara fizikal sama ada melalui sentuhan ataupun cahaya. Selain itu, kaedah praktikal sedia ada mempunyai kekangan dari segi masa (memakan masa) dan hanya melaporkan anggaran populasi dan bukannya bilangan tepat individu kelawar di sesuatu tapak kajian. Di dalam kajian ini, konsep *Light Detection and Ranging* (LIDAR) di aplikasikan dengan menggunakan peralatan *Terrestrial Laser Scanner* (TLS) digunakan secara capaian jauh bagi mendapatkan bilangan populasi serta identifikasi spesies kelawar di dalam gua. Pancaran laser akan mengimbas gua secara jitu untuk merakam kedudukan ruang kelawar serta gua dalam bentuk tiga-dimensi (3D) didalam keadaan gelap gelita. Penggunaan LIDAR membolehkan bilangan individu kelawar ditentukan di samping menganalisis taburan kelawar secara spatial dan juga menghasilkan struktur tiga dimensi topologi gua. Hasil pengimbasan ini menghasilkan model gua dengan resolusi tinggi yang membolehkan kelawar dikira dan jumlah populasi kelawar di dalam gua dapat dipetakan. Melalui kaedah ini, dua (2) spesies kelawar dapat dikenalpasti iaitu *Hipposideros larvatus* dan *Hipposideros armiger*. Kajian ini dijangka dapat membuktikan bahawa penggunaan LIDAR akan membuka ruang baru dalam kajian berkaitan kelawar. Hasil dari kajian ini berupa satu prosedur untuk mendapatkan bilangan populasi kelawar secara automatik dan membuktikan bahawa kegunaan data *point cloud* dapat membantu pengenalpastian spesies kelawar.

Kata kunci: Imbasan Laser, Kelawar, Kajian Populasi, Pengiraan Automatik