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Study uses animal-born sensors, machine learning to reveal chinstrap penguin prey captures

Foraging chinstrap penguins Photo: Chris Oosthuizen

A new study led by researchers at the University of Cape Town (UCT) linked animal-born video and movement sensor data with machine learning algorithms, to reveal how chinstrap penguins catch their prey. This will enable scientists to monitor prey consumption by these penguins, which will provide information that can help to inform conservation strategies.

"Our understanding of penguin foraging behaviour has rapidly grown during the last decades, as innovations in technology allowed ever more powerful remote monitoring," said Dr Chris Oosthuizen, a research fellow at the [Centre for Statistics in Ecology, the Environment and Conservation (SEEC)] at UCT. "Today, ecologists have access to a wide range of tags and sensors that can accurately measure animal position, diving depth, movement behaviour, and aspects of the environment that the animal encounters. This has opened exciting new avenues for ecological research."

Through an innovative blend of machine learning and animal-borne sensors, the new study published this month in the peer-review journal *Royal Society Open Science*, aimed to develop a method to detect individual prey captures of Antarctic krill by wild chinstrap penguins.

"We are interested in the foraging decisions and foraging efficiency of chinstrap penguins. We want to know how the penguins' foraging efficiency changes in time and space, and in relation to external factors, but first had to develop a method to quantify prey capture rates in free-living penguins," explained lead author Dr Stefan Schoombie, a postdoctoral fellow at SEEC and associate of South Africa's National Institute for Theoretical and Computational Sciences (NITheCS).

The team used waterproof tape to attach miniature video cameras and tags with acceleration and pressure sensors to the backs of penguins. Each adult penguin equipped with these backpacks collected data for a single foraging trip at sea.

"The video footage gives us direct signals of prey capture events and context of the environment that the penguin is foraging in," said Schoombie. "The other sensors measure the dynamics of movement and the penguins' diving depths. We used the video footage to visually confirm when the penguins were catching prey, and then employed supervised machine learning based on deep neural network architectures to train on accelerometer and depth data. In the absence of video data, the trained models can now identify prey capture events from new acceleration and depth data. This was the goal, as video recording duration is typically only a few hours (compared to several days for the other sensors) and video data quality depends on ambient light conditions, as well as water clarity. Chinstrap penguins can capture up to three prey items per second, and our results show that the deep learning algorithms can identify most of these captures".

As in other fields of science and technology, the integration of animal-borne sensors and machine learning techniques is a powerful approach to enhance wildlife monitoring.

Co-authors Drs Lorène Jeantet and Emmanuel Dufourq, researchers at the African Institute for Mathematical Sciences (South Africa, and Research and Innovation Centre, Rwanda), Stellenbosch University and NITheCS, explained that deep learning is an effective tool for automating analyses from high-resolution sensors such as accelerometers, which collected tri-axial acceleration data at 25 Hz in this study. "In many ecological fields, the advent of sensor technology transformed traditional observation methods to the use of high-resolution data collection through sensors. Animal-borne sensors now provide continuous, high-resolution data on movement and behaviours, allowing large amounts of data to be recorded. It was therefore essential for analyses methods to evolve as well. Deep learning algorithms can rapidly process these large datasets. By applying deep learning approaches, we can now automatically detect animal behaviours like feeding patterns over long sampling periods. In our study, these algorithms not only performed classification tasks faster than human observers would be able to, but also detected patterns in the data that was difficult to observe visually."

Quantifying krill consumption by chinstrap penguins and other marine predators is vital to understanding trophic relationships, predicting future population dynamics, and informing resource management strategies.

"In the Southern Ocean around Antarctica, conservation and fisheries are managed by the Commission for the Conservation of Antarctic Living Marine Resources (CCAMLR)," said

Oosthuizen. "CCAMLR is currently working towards improved ecosystem-based management strategies, and our results can contribute to their programs of research and monitoring of krill-dependent predators to contribute to the conservation of Antarctica's wildlife".

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For interviews, please contact Dr Chris Oosthuizen.

Access the study.

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