



## Case study on the diving ability of the Bajo tribe in Indonesia

### *Estudio de caso sobre la capacidad de buceo de la tribu Bajo en Indonesia*

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#### Abstract

**Introduction:** The Bajo community possesses remarkable abilities and has been the focus of various studies. However, a comprehensive understanding of the complex factors influencing their diving capabilities remains incomplete.

**Objective:** This study explores the extraordinary freediving abilities of the Bajo people in Wakatobi, Indonesia.

**Methodology:** Using a qualitative case study approach. Data were collected through observations and interviews with 20 diverse informants. Thematic analysis was used to uncover key aspects of Bajo diving, including factors influencing performance (age, health, and genetics), specific techniques (a combination of freestyle/breaststroke strokes and varying body positions), typical dive duration (3-10 minutes) and depth (15-30 meters), training methods (observation, independent practice, and community guidance starting at a young age), and simple traditional equipment (wooden goggles and spears).

**Results:** The results demonstrate a profound interaction between the marine environment and socio-cultural practices in shaping the extraordinary diving abilities of the Bajo people, highlighting their close relationship with the sea and providing valuable insights into the Bajo people's adaptations to traditional diving.

**Discussion:** This study emphasizes the significant influence of the marine environment and socio-cultural traditions on the exceptional diving abilities of the Bajo community, which distinguishes their traditional methods from modern diving practices and equipment.

**Conclusions:** The diving culture of the Bajo community needs to be preserved while also providing health education regarding the risks associated with diving activities. This culture could be developed into a professional sport, potentially having a more substantial impact on the lives of the Bajo people.

#### Keywords

Diving performance; diving techniques; underwater dives; diving ability.

#### Resumen

**Introducción:** La comunidad del Bajo posee habilidades notables y ha sido objeto de diversos estudios. Sin embargo, aún no se ha logrado una comprensión completa de los complejos factores que influyen en sus capacidades de buceo.

**Objetivo:** Este estudio explora las extraordinarias habilidades de apnea del pueblo Bajo en Wakatobi, Indonesia.

**Metodología:** Utilizando un enfoque de estudio de caso cualitativo, se recopilaban datos mediante observaciones y entrevistas con 20 informantes diversos. Se utilizó un análisis temático para descubrir aspectos clave del buceo bajo, incluyendo factores que influyen en el rendimiento (edad, salud y genética), técnicas específicas (una combinación de brazadas de estilo libre/braza y diferentes posiciones corporales), duración típica de la inmersión (3-10 minutos) y profundidad (15-30 metros), métodos de entrenamiento (observación, práctica independiente y orientación comunitaria desde una edad temprana) y equipo tradicional sencillo (gafas de madera y lanzas).

**Resultados:** Los resultados demuestran una profunda interacción entre el entorno marino y las prácticas socioculturales en la configuración de las extraordinarias habilidades de buceo del pueblo Bajo, destacando su estrecha relación con el mar y brindando información valiosa sobre las adaptaciones del pueblo Bajo al buceo tradicional.

**Discusión:** Este estudio enfatiza la influencia significativa del ambiente marino y las tradiciones socioculturales en las excepcionales habilidades de buceo de la comunidad de Bajo, que distingue sus métodos tradicionales de las prácticas y equipos de buceo modernos.

**Conclusiones:** Es necesario preservar la cultura del buceo en la comunidad del Bajo, a la vez que se brinda educación sanitaria sobre los riesgos asociados con las actividades de buceo. Esta cultura podría convertirse en un deporte profesional, lo que podría tener un impacto más significativo en la vida de los habitantes del Bajo.

#### Palabras clave

Rendimiento de buceo; técnicas de buceo; inmersiones submarinas; capacidad de buceo.

## Introduction

The Bajo community relies on marine natural resources and is deeply connected to life in the marine and coastal environments (Maulidyna, Hartawan, Agustin, Irffan, et al., 2021), which has led to them being known as "sea nomads" due to their subsistence lifestyle, renowned for their exceptional breath-holding abilities (Ilardo et al., 2018a). Traditional Bajo divers dive without using modern diving equipment. These diving skills are passed down from generation to generation within the family environment. They rely on their ability to hold their breath to search for shells, retrieve lost equipment, and do other activities. Some traditional divers can dive to depths of 60-100 feet (Kindwall, 2004) even with inadequate support and not following standard operating procedures (Ahdar et al., 2020). They always pray to the Almighty for safety before diving (Mallapiang et al., 2023) and equip themselves with leather or rubber goggles to equalize the pressure underwater, a practice that was introduced around 150 years ago. For example, Cachido divers swim unaided to a depth of 7 meters with only a support buoy, and most of their dives take less than 1 minute. Funado divers dive from boats with the help of weights and lines to a depth of 20 meters. Italian diver Raimondo Bucher set a record for diving 30 meters in a single breath in 1949. Some divers also compete without fins in breaststroke to the maximum depth without equipment (Fitz-Clarke, 2018).

Diving activities pose risks for beginners due to various issues they may encounter. Breath-holding divers can experience neurological involvement, particularly cerebral events such as strokes, potentially leaving the spinal cord affected (Kohshi et al., 2021). When a diver descends to around sixty feet, the air in their lungs becomes highly compressed, making buoyancy negative, which causes them to sink rather than float. In addition, divers descend to very deep depths, and their eardrums sometimes rupture. Although not fatal, this is painful and can cause temporary loss of balance. When diving, many hold rock weights to help them descend quickly without expending valuable oxygen to swim down (Dawson, 2006). However, the aids (rocks) used to dive at depths greater than 20 meters pose a significant risk to the safety and health of divers. Therefore, diving must be carried out under certain conditions and using standard diving equipment such as scuba (Sukbar et al., 2016). Scuba offers a positive way to explore the underwater world and brings physical and psychological benefits to divers (Gerungan & Chia, 2020). In the context of scuba diving, responsible diving behavior significantly influences their diving experience, indicating that specialized divers have a positive impact on their attitudes (Ong & Musa, 2012).

Behind the various aids to facilitate diving activities, there are several tribes in the world (including Indonesia) who have natural talents that affect their traditional diving abilities without modern breathing apparatus. They may have different behavioral, cognitive, and affective perspectives on diving activities, so in addition to being a means of recreation and economy, they are also responsible for maintaining ecological stability for their marine environment. For example, strengthening local wisdom through the tradition of pamali (taboo) for marine resource conservation, which regulates the sustainability of ecosystems and marine biota (such as fishing or collecting marine products around coral reefs) (Basri et al., 2017). The high level of ecological knowledge and education among divers has a strong influence on their responsible behavior toward the environment. Environmental behavior includes knowledge of issues, action strategies, locus of control, attitudes, verbal commitment, and a sense of responsibility (Thapa et al., 2005). Other studies focus on analyzing human factors during dive training conducted by professional scientific divers. The aim is to understand individual variability and how it affects team performance, especially under stressful conditions such as cold weather, workload, and fatigue. In diving situations, cold weather and poor visibility are the main causes of environmental stress, and fatigue has the greatest physical impact on divers (O'Brien & Caramanna, 2017).

Divers with special skills tend to be more aware of undesirable conservation behaviors, such as losing buoyancy and touching marine mammals (Salim et al., 2013). In addition, the economic aspects of diving activities have also been studied, such as the willingness of divers to contribute to the costs of marine environmental management carried out by Dutch and Belgian Divers for trips to the Oosterschelde dive site can reach 21.7 million Euros per year (Rousseau & Tejerizo Fuertes, 2020). Other studies have used structural equation models to show the causal relationship between divers' experiences, personalities and attitudes with their underwater behavior. Taking a picture of previous research, the current study points to the importance of education and culture in developing diverse skills and knowledge practices. The strong influence of diving experience and attitudes on behavior indicates the importance of diving



and marine education in developing skills and knowledge practices among divers. Success in shaping underwater diver behavior requires collective efforts from various stakeholders, including divers, operators, diving associations, marine conservation organizations, and government agencies (Ong & Musa, 2012).

However, several research gaps need to be filled regarding the factors that influence the diving ability of the Bajo people. The life of the Bajo people is thick with the tradition of fishing, the tradition of *mamia kadialo* (values of preserving marine and coastal ecosystems), behavior towards catches, and community knowledge about marine and coastal natural phenomena (Sir & Mannan, 2023) which they interpret that the sea is a force that makes them "alive" (Maemunah et al., 2022). This fishing culture gives the Bajo people interesting abilities and has been the focus of various studies. However, a comprehensive understanding of the complex factors influencing their diving ability has not been fully answered. Therefore, this study aims to holistically analyze the various factors that contribute to the diving ability of the Bajo people. With a multidisciplinary approach, this study provides new insights into the complex interactions between humans and the marine environment and its implications for traditional diving practices.

## Method

This study uses a qualitative research approach to describe, explore, and understand the meanings ascribed to social or humanitarian issues (Creswell & Creswell, 2018). The researcher used the case study method to explore the diving abilities of the Bajo people in depth (Creswell & Creswell, 2018). The case was limited by time and activity, and the researcher collected detailed information using various data collection procedures over a continuous period of time.

To accommodate the research data, we involved 20 informants consisting of fishermen, the general public, community leaders, athletes, and coaches who were determined using snowball sampling. This technique explains that the initial informant will recommend other informants relevant to the research topic (Neuman, 2014). For example, researchers start by first interviewing several community leaders and the general public, after which they recommend the data that has not been fulfilled to competent individuals who have direct experience with diving activities (such as fishermen) so that the aspirations conveyed can answer the needs of the research objectives. We also pay attention to research ethics by obtaining informed consent from all participants, ensuring anonymity and confidentiality of data, avoiding exploitation and discrimination, and ensuring that this research does not endanger participants or the environment.

This research was conducted in the Bajo Tribe in Wakatobi Regency, Southeast Sulawesi Province, which is the largest Bajo tribe population in Indonesia. The research location includes five villages spread across Wangi-Wangi Island, including the Wakatobi Regency with five villages called Mola Raya, consisting of South Mola Village, North Mola, Bahari Mola, Samaturu Mola, and Nelayan Bakti Mola (Hewi, 2015). Meanwhile, the Bajo tribe village on Kaledupa Island, Wakatobi Regency, consists of two villages: Sama Bahari Village and Mantigola Village. Thus, the total number of research locations is seven villages.

Furthermore, data collection was carried out by direct observation (participatory and non-participatory), semi-structured interviews, and documentation. First is the participatory observation method, namely by being directly involved in the diving activities of the Bajo people to directly observe how the Bajo people experience diving activities, while non-participatory observation is carried out by observing from the outside without being directly involved. Second, 50 semi-structured interview guidelines covering questions about diving experiences, factors that influence diving ability, diving techniques, the role of culture and tradition, environmental impacts, and challenges and changes in traditional diving practices. Finally, documentation by reviewing previous documents and audio-visual files relevant to the research theme, including the activities of the Bajo people in diving and so on.

The data analysis technique used in this study refers to the thematic data analysis technique developed by Naeem et al. (2023). First, transcription, familiarization with the data, and selection of quotations: The researcher transcribes the data and explores the content in depth to understand the initial theme by establishing reference codes representing various perspectives and patterns relevant to the research

objectives. Second, the selection of keywords, namely examining observation data, interviews, and documentation carefully to identify definitions, patterns, or elements that emerge and determine them as keywords that reflect the perceptions and experiences of participants. Third, coding, namely, researchers code phrases from data segmentation to reduce core messages, significance, or themes or reduce textual data into theoretical forms and help identify elements coherent with research objectives.

Fourth is theme development, namely organizing codes into meaningful theme groups by identifying patterns and correlations and transitioning detailed analysis of codes and categories to more abstract interpretations by creating themes. Fifth, conceptualization is interpreted through keywords, codes, and themes. Researchers identify social patterns and refine them into definitions that align with the study's main objectives using various visualization tools such as diagrams or models to clarify the relationships between these concepts. Sixth is the development of conceptual models; researchers present unique data that refer to previous theories. Models serve to answer research questions and underline the contribution of research to the development of current science as a reflection of certain social experiences.

## Results

### *Factors affecting diving ability*

#### *Age*

Undoubtedly, a person's diving ability is greatly influenced by their age. As a person ages, the anatomical functions of the human body undergo changes that impact physical performance. For example, Informant 1's opinion that age greatly influences people who are over 40 years old. Conversely, if they are under that age, they are still constant and have good diving abilities. This statement is supported by the view of Informant 12, who said that he is now over 40 years old, and at that age, he could only dive for 2 minutes, different from his previous age when he could dive for more than 2 minutes. It means that age also greatly influences diving ability, making it less effective than before.

Another perspective was also expressed by Informant 17, who explained that the Bajo community views genetic mutations through physical traits. The Bajo community is indeed different from people outside us. Indeed, there are tall people here, but the standardization is only lower (shorter body size). Then, when they dive, they only wear ordinary glasses, and even their breathing is comparable to people who use gas cylinders when diving. Diving activities that have been part of the culture since childhood and adolescence allow their bodies to adapt to physiological functions well. However, various other external factors, such as drinking alcoholic beverages and staying up late, have affected breathing while diving and physical conditions become weak. However, their physiological functions are still trained at that age, and they are superior to carrying out diving activities with other people of the same age.

#### *Smoking Habit*

Another factor that affects diving ability is the habit of smoking. Informant 1 shared the opinion that smoking can reduce diving ability. Similarly, Informant 17 supported this statement, mentioning that aside from affecting diving ability, smoking also weakens the body's endurance. Therefore, the smoking habit significantly impacts diving ability, as it also weakens physical endurance. This happens because smoking can damage lung tissue and reduce overall lung capacity. Damaged or impaired lung function cannot supply oxygen efficiently to the body, which is crucial when diving at greater depths. When oxygen cannot be absorbed effectively by the body, diving endurance becomes suboptimal or diminished, making it difficult for the diver to spend more time at deeper depths in the water.

#### *Health Condition*

Health conditions also greatly affect diving ability. Several diseases are often experienced by the Bajo Tribe people who often dive, including those stated by Informant 14. According to him, he already has a stomach ulcer, and if he feels an earache, he usually massages his nose until a sound appears in his ear. In addition, he often feels his nose bleed and feels that if it is like that, he is stronger in diving because his head does not hurt anymore, and he decides to continue diving. Information about earache is also supported by the statement of Informant 17, who explained that if the health condition of our fishermen divers is seen from their medical records, I rarely see fishermen who are sick, like catching a cold, and



most do not. If the diver is at a very high depth and is not a ruptured ear, it must be muscle cramps. However, if divers are used to it, like in the seabed, they rarely have earaches, depending on the depth. So, the health conditions of fishermen who often dive too deep into the diseases include ulcers, colds, ear and nose disorders, and muscle cramps.

### ***Techniques used by the Bajo tribe when diving***

#### *Start or Jump when Diving*

The starting technique is divided into two stages: jumping and underwater. According to Informant 17, jumping is conditional depending on the location; if it is deep, start with the head. However, they usually start with their feet first because they do not immediately dive but only swim to find a better diving position, or they want to use the time to swim leisurely in the sea area. However, things are different if they want to do it underwater. As expressed by Informant 9, when underwater, they use the freestyle leg technique to provide a strong push to the body, and both hands split the ocean to direct their bodies towards the depths of the sea. Therefore, they prefer to use their heads when jumping to provide strong pressure when diving to the bottom of the sea. Thus, the starting technique used by the Bajo Tribe when jumping is that the feet touch the sea water first, then when underwater, they use freestyle leg movements and breaststroke hand movements.

#### *Body Position when Diving*

When entering the water, the body's position determines the speed and efficiency of energy and breathing. Therefore, when in the water, all external human organs, such as the legs, waist, hands, and head, are usually used optimally. The body position of the Bajo Tribe when diving, according to Informant 1, is when diving, the body position is down (vertical) and when rising, like walking and a "frog" position to provide a strong and fast push to the surface. Usually, they consider breathing with movement activities in the water, so the more their breathing is uncontrolled, the more their bodies become more agile, ensuring they reach the water's surface faster. Meanwhile, Informant 14 said his body position was slightly tilted with his feet up and his head down because he had not yet mastered the straight body position down when diving. So, the body position of the Bajo people when diving is slightly tilted, the feet up, the head down, and when rising to the surface of the water, like walking. However, this condition is very dynamic according to their diving and breathing abilities to avoid accidents (light and heavy) while at sea.

#### *How to Breathe while Diving*

According to Informant 1, the way of breathing that is often done and practiced by the Bajo people when diving is to hold their breath until they cannot hold it, then exhale little by little. A similar thing was also expressed by Informant 4; he said that when diving, someone must hold their breath, and if they release it, they must immediately rise to the surface of the water. So, when the Bajo people dive, the way of breathing is to hold their breath after they cannot hold it, then exhale little by little and go straight to the sea's surface. This means that the diving techniques used by the Bajo people are also different. According to Informant 1, they usually land their buttocks first. Meanwhile, according to Informant 4, he prefers to land his head first. Then, both continue diving with freestyle legs and breaststroke arms. In addition, informant 14 admitted that in addition to diving with the same style, he sometimes holds an arrow or spear in one of his hands. While informant 12 argued that the diving technique is the same, the difference is the breathing technique and without aids. The choice of breathing technique may depend on the individual's comfort and experience. So, the diving technique carried out by the Bajo Tribe uses freestyle leg movements and breaststroke arm movements.

### ***Water depth and longest time diving***

#### *How Long can You Dive in Water Depths*

Informant 4, a rowing coach and village head, said that he could still dive for 3 minutes and some could reach more than 7 minutes, but this ability decreases with age. Furthermore, Informant 8, a fisherman who usually dives to find fish by shooting arrows, said that at around 39 years old, he could only dive for up to 2.5 minutes. Meanwhile, his other brother could only survive diving for 1.5 minutes because he was older than him. Furthermore, he added that it could be up to 3 minutes if forced, and diving down could be up to 5 minutes. Informant 12, also a fisherman, explained that he could dive for around 5-10



minutes at around 20-30 years old. Furthermore, informant 19 said it was impossible to get fish in only 5 minutes, and if it was up to 10 minutes, it was possible. He added that it must be more than 5 minutes because it takes a long time to find several fish and to come to the surface. Meanwhile, informant 20 and a fisherman also said that when he was around 30 years old, he could dive for 5 to 6 minutes, but now that he is old, he lacks energy. Researchers also observed by holding diving competitions how long the Bajo Tribe people can dive in the water depth, which is an average of around 3-10 minutes, at the age of around 20-30 years.

#### *What is the Water Depth while Diving*

The water depth that can be reached by the Bajo Tribe when diving varies greatly, according to several informants. For example, in Informant 4, in elementary school, he could dive for 3 minutes at a depth of 15-30 meters. Informant 10, who had experience diving in Bali, stated that he reached a depth of 30 meters and below measured in fathoms, around 25-30 fathoms, and 1 fathom is equivalent to 2 meters. Informant 12, at age 20, could dive up to 30 meters, but now, at 50, his ability has decreased to 20 meters. Informant 14 explained that they could dive more than 20 fathoms or around 30 meters down, and at 25, he reached 15 fathoms. Finally, Informant 20, at age 30, could dive up to 14 fathoms or 21 meters, so he could reach 42 meters by diving back and forth. So, the conclusion is that how many meters deep the water is when the Bajo people dive is around 30 meters below the sea, measured using fathoms, and 1 fathom is usually an average of 1.5 meters at an average age of 20-30 years.

#### **Preparation, training process, and regeneration of diving ability**

##### *Courage is the Main Asset in Diving Training*

According to Informant 4, the Bajo Tribe people do not have special preparation before diving; instead, learning to dive is done autodidactically, with parents or friends. They have a unique tradition of training their diving skills by competing to take sand at a certain depth and raw chicken eggs left over from medicine on the seabed, which must then be eaten raw. A similar thing was also expressed by Informant 12, that when he was 12 years old, he climbed onto his back, and his parents dived into the sea. If I cannot stand it and am strong, I let go and come up to 5 meters. After adjusting my breathing, I will talk to my parents and go down again. This experience shows that diving is a habit carried out from generation to generation and is the main livelihood of the Bajo Tribe people.

Furthermore, Informant 17 said that he teaches children to build courage first before going into the sea and diving. Sometimes, children cry when asked to take a bath, but if they dare to take a bath in the sea, they are ready to dive. When there is a ladder, we ask them to stand close to us first; the important thing is that they dare to let go of the handle of the ladder towards where we are standing. If they are braver, we start to move away a little the next day and let go of both of their hands. When diving, informants have invited their children to jump here, and they still do that to their children, so now they have become swimmers and divers, too. Thus, courage is the basic capital for children to train them to swim and dive. and below measured in fathoms, around 25-30 fathoms, and 1 fathom is equivalent to 2 meters. Informant 12, at age 20, could dive up to 30 meters, but now, at 50, his ability has decreased to 20 meters. Informant 14 explained that they could dive more than 20 fathoms or around 30 meters down, and at 25, he reached 15 fathoms. Finally, Informant 20, age 30, could dive up to 14 fathoms or 21 meters, so he could reach 42 meters by diving back and forth. So, the conclusion is that how many meters deep the water is when the Bajo people dive is around 30 meters below the sea, measured using fathoms, and 1 fathom is usually an average of 1.5 meters at an average age of 20-30 years.

##### *Diving Ability Regeneration Process*

Several references have been revealed regarding the process of diving ability regeneration of the Bajo Tribe. For example, Informant 8, a fisherman, said that his father taught him to join in diving on his shoulders. He would immediately go up and try again if he could not stand it. He even tried taking sand to the bottom of the sea about 10 meters down and going up 10 meters. Then, Informant 12 added that since long ago, when he was 12 years old, he always dived into the sea with his parents. If 5 meters were not strong enough, he would be released and come to the sea's surface, then try again the next day. He also emphasized that the process was deliberately passed down to boys from adolescence until 18 years old by regulating their breath and not rushing when diving.



Furthermore, according to Informant 14, their parents taught them how to dive, how not to get earaches, how to dive at depth, and how to dive so as not to get tired. He emphasized that we must breathe slowly and regularly when diving because if we quickly dive down to the bottom or bottom, we definitely will not be strong. If we take a breath as hard as possible, our breathing will run out quickly, whereas if we are slow and gentle in our movements, our breathing will still be long. Finally, Informant 17 revealed that he taught his children to build courage first before going down to the sea and diving. If they are braver, they move away a little the next day and release both hands. He added that he once invited them to jump into his place when diving, and he still does that to his children now, so they have become swimmers and divers, too.

The preparation, training process and regeneration of the Bajo people's diving ability begin with assessing courage and learning to control breathing to avoid rushing when diving. The initial training involves jumping into shallow or deep water, guided by parents or friends. Once they can jump and swim independently, they accompany their parents by holding onto their backs while diving into the sea. If they cannot endure it, they immediately let go and return to the surface to catch their breath before attempting to dive again.

### ***Assistive tools used, characteristics of skilled divers, and agreed rules while diving***

#### *Assistive Tools used During Diving*

Assistive tools are essential equipment used by the Bajo people while diving. Informant 8 stated that they only wear underwear and wooden-framed goggles, with lenses made from repurposed glass from houses. They also use wooden arrows, iron bows, rubber made from stainless steel, and spears. Informant 20 added that he does not wear shoes, only regular shorts, and rarely wears a shirt. He also uses wooden goggles but does not use fins. Meanwhile, Informant 14 explained that the Bajo people can dive for long periods without assistive tools. They relieve ear pain by pinching their noses until their ears pop, and nosebleeds indicate increased endurance for deeper diving. Based on interviews and observations, the assistive tools used while diving include wooden-framed swimming goggles with lenses made from repurposed glass and straps made from tyre rubber. The arrows are made of wood, the bows are made of iron, and the rubber is made of stainless steel. Additionally, the spears have wooden handles with iron tips. Most divers wear only underwear or regular shorts and do not use swimming fins.

#### *Characteristics of Skilled Divers*

At a glance, the Bajo people can identify individuals with exceptional diving skills. Informant 5 explained that a skilled diver's characteristics can be observed through strength, swimming speed, and diving ability. Meanwhile, Informant 17 added that physical traits also play a role, such as the difference in muscle structure between swimmers and divers. Swimmers tend to have more muscular builds, while divers are recognizable by their naturally faded, yellowish hair and darker skin tone than swimmers. In conclusion, the characteristics of skilled divers among the Bajo people can be identified by their strength and diving speed. They often have a distinct muscle structure, naturally yellowish hair, and dark skin.

#### *Agreed Rules while Diving*

The Bajo Tribe has several rules that must be agreed upon when diving. Informant 10 explained that there is no prohibition or rule prohibiting diving. However, when there are strong winds from the East between July and September, especially in July, diving is not allowed, although it is not always obeyed. Before going to sea, they follow customs such as throwing betel as a notification to the ruler of the sea, especially if diving or going to sea for a long time or far away, while for those who are close by, this ritual is not necessary. Informant 17 added that if someone dies during the 7 days, a goat is usually slaughtered, which is strictly prohibited for people going to sea. This prohibition still applies and continues to be socialized from generation to generation.

In addition, when diving or going to sea, it is not allowed to curse, say rude words, say dirty words, and litter in the sea. If they violate, they will be sanctioned by their ancestors, and Friday is also considered taboo for carrying out these activities. Furthermore, according to Informant 18, rituals are sometimes carried out in the Bajo tribe, such as giving Slipinan birds, or there is a term called Itukwara. The term is, our parents are hot water is one of the things we offer to those in the sea, such as arak water.



So, several rules are agreed upon when diving: if there is a strong wind from the east between 7-9, it is advisable not to dive. Then, before going to sea, follow customs such as throwing betel and arak; the aim is to notify the sea ruler; this is done if diving or going to sea for a long time or far. Furthermore, for example, 7 days after someone dies, usually a goat is cut; this is strictly prohibited if people go to sea; when diving or going to sea, you are not allowed to curse, say rude words, say dirty words, and litter in the sea.

## Discussion

### *Factors affecting diving ability*

Even though the Bajo people's diving abilities are extraordinary, various factors that can influence them. Some of these factors can limit or even reduce their ability to dive. One significant factor is the habit of consuming alcoholic beverages. Alcohol can negatively affect the respiratory and cardiovascular systems, which are important for diving activities. Excessive alcohol consumption can disrupt with the body's ability to regulate breathing and heart rate, thereby reducing endurance and increasing the risk of health problems when diving. In addition, the habit of staying up late can also affect diving ability. Lack of sleep can cause fatigue and a decrease in general physical condition. It can affect muscle strength, coordination, and cognitive abilities, which are important for safety and efficiency when diving.

According to Pilcher and Huffcutt (1996) study of 1932 samples, sleep deprivation significantly disrupts human function. Although not specifically examined in the current qualitative study, humans can contract the spleen and increase circulating hematocrit, which can improve apnea performance by increasing gas storage so that spleen and lung volume predict apnea performance in divers (Schagatay et al., 2012). Genetic predisposition and environmental exposure determine the size of the human spleen (Holmström et al., 2020). Furthermore, research by Maulidyna et al. (2021) found that genetic factors can explain the differences in spleen size between the Bajo tribe and other tribes. The spleen has an important role in storing oxygen and releasing red blood cells, which can affect the ability to hold one's breath while diving. Not only that, the gene mutation process occurs during the marriage process, both with fellow Bajo and from outside, so that the genes of the Bajo tribe's descendants can mix with their partners. Natural selection on genetic variants has increased spleen size in Bajau people, providing them with a larger reservoir of oxygenated red blood cells (Ilardo et al., 2018).

Other factors such as age also greatly affect diving ability, making it less than before. Abrahamsson and Schagatay (2014) explained that Bajau Laut children have good underwater vision, which allows them to collect small shellfish without using goggles. The oldest divers, aged between 55 and 65, are still successful fishermen, but their fishing trips tend to be shorter with significantly reduced underwater working hours. Siagian et al. (2023) also revealed that most traditional divers are around 40 years old, with the oldest being 64 years old. The ideal age for divers is 16-35 years, so divers over 35 are still allowed to dive if they have good physical and mental health. Research conducted by several of the researchers above stated that it supports the importance of adequate rest for optimal body function. Their analysis shows that overall lack of sleep greatly interferes with human function, including breathing and physical performance.

Breath-hold diving involves environmental challenges, such as water immersion, hydrostatic pressure, and asphyxia, which pressure the respiratory system (Tetzlaff et al., 2021). Therefore, in addition to age factors, smoking habits also greatly affect diving ability, which is reduced, and also affects the body's resistance to becoming weak. According to Oetama et al. (2019), risk factors such as smoking habits and lack of exercise affect the lung function of fishermen. The health conditions of fishermen who often dive too deep include ulcers, colds, ear and nose disorders, and muscle cramps. The ability to quickly equalize the air in the middle ear and sinuses with increased hydrostatic pressure is also important for human diving; without this, the eardrum can rupture (Schagatay, 2014). This means that diving is not without risk because the deeper the diver dives to the seabed, the lungs will be exposed to increased O<sub>2</sub> pressure. The more often a person dives, the greater the risk of lung disorders, usually causing ear and nose disorders (Arhesa et al., 2024)

A study by Maulidyna et al. (2021) reported that hearing impairment is the most common yet often overlooked health issue among the Bajo community. Among 47 Bajo community respondents in Bone





Regency, South Sulawesi, 27 or around 49.15% experienced hearing loss. Although they are sea people with excellent diving skills, Bajo divers can also experience health problems if they dive too deep and for too long in the sea. The Ministry of Health's survey data report on 251 diver respondents from 9 provinces in Indonesia found that 56.6% of divers used the diving technique of holding their breath, 33.9% were compressor divers, and 9.6% used scuba. The complaints frequently obtained from the 251 respondents included 21.2% dizziness/headache, 12.6% fatigue, 12.5% hearing loss, 10.8% joint pain, 10.2% nosebleeds, 9.7% chest pain/tightness, 6.4% vision loss, 6.0% red spots on the skin, 5.6% animal bites, 3.2% paralysis, and 1.7% loss of consciousness.

### ***Techniques used by the Bajo people while diving***

The influence of the environment on the diving performance of the Bajo Tribe in Indonesia is very large and interrelated between physical (natural) and socio-cultural factors. The environment has shaped their extraordinary diving abilities through biological adaptation and knowledge, traditions, and practices passed down from generation to generation. The Bajo Tribe has a unique diving start technique. They do not immediately dive into the water but instead take a run-up by jumping. When jumping, their feet are the first part of their body to touch the surface of the seawater. It allows them to enter the water optimally to start the dive. After entering the water, their underwater technique is also unique. They use a combination of freestyle leg movements and breaststroke arm movements. The freestyle leg movements provide a strong forward thrust, while the breaststroke arm movements help them maintain balance and direction underwater. Combining these two styles allows them to move agilely and efficiently in the water.

According to Maharani (2022), the dolphin-like style is permitted underwater as long as it remains beneath the water's surface. The dolphin style involves flexible body movements and strong leg thrusts, allowing divers to move quickly and efficiently in the water. The start and underwater techniques used by the Bajo people are an effective combination of jumping, freestyle leg, and breaststroke arm movements. This technique allows them to dive quickly, efficiently, and agilely in the water, making finding fish and other marine resources easier. In addition to the typical start technique, the Bajo people also have a unique diving technique. They use a combination of freestyle leg movements and breaststroke arm movements to propel their bodies through the water. Freestyle leg movements provide forward thrust, while breaststroke arm movements help maintain balance and direction. Their body position while diving is also adjusted, as it affects the difficulty of a person's dive (Zhang et al., 2021). They tilt their bodies slightly, with their feet above and their heads below. This position allows them to reduce water resistance and move more efficiently. When they start to rise to the water's surface, their movements resemble people walking in the water, helping them gain momentum and reach the surface quickly. When gliding, both through interviews and direct observation, it was seen that the Bajo people maintained a straight body position above the sea surface. Their legs and arms remain still, reducing drag and allowing them to glide smoothly. They hold their breath during the glide, using their trained lung capacity to maximize their time underwater.

The breathing technique of the Bajo people when diving is the key to their extraordinary abilities. They start the dive by taking as many deep breaths as possible to maximize the oxygen in their lungs. Then, they hold their breath during the dive. This ability to hold their breath has become their trademark, even attracting the attention of researchers. According to Ilardo et al. (2018), the indigenous Bajau people are known as sea nomads in Southeast Asia, living a subsistence lifestyle that relies heavily on diving while holding their breath. They are renowned for their extraordinary ability to hold their breath, which allows them to dive deeper and longer to find food in the sea. When they start to feel like they cannot hold their breath, they do not immediately rise to the surface but exhale little by little to conserve the remaining oxygen. This technique allows them to extend their dive time and maximize their catch. Once they have had enough, they immediately rise to the sea's surface to take another breath. This process is repeated continuously while they dive.

Abrahamsson and Schagatay (2014) study highlighted that many members of the Bajau Laut community rely on breath-hold diving as their primary means of earning a living (catching fish, shellfish, sea cucumbers, and other seafood sources). Interestingly, they often do so without using modern diving equipment or with simple equipment such as swimming goggles or simple spears. It shows their extraordinary adaptation to the marine environment and natural abilities developed over generations. Oetama et al.



(2019) also emphasized that breath-hold diving is a traditional method that has long been used by fishermen in various communities, including the Bajo Tribe. This technique allows them to directly utilize marine resources with relatively minimal risk compared to more modern and invasive fishing methods. These two studies provide a clear picture that breath-hold diving is not only a skill but also an integral part of the culture and identity of the Bajau Laut community. This ability allows them to live in harmony with the sea, utilize its resources sustainably, and maintain traditions passed down from generation to generation.

### ***Preparation, training process, and regeneration of diving ability***

The Bajo people are known to have extraordinary diving skills, largely due to their intense interaction with the marine environment from an early age. Bajo children learn to swim and dive at a very young age, even before they can walk, as Abrahamsson and Schagatay (2014) explained. They are introduced to the sea by their parents or siblings, and through everyday experiences, they develop natural diving skills. This natural diving skill is reflected in some of the physical characteristics and abilities they have. Some physical characteristics often associated with good diving skills include strong muscles, naturally yellow hair, and dark-toned skin. Not only that, Maulidyna et al. (2021) added that the Bajo people are known as a tough, assertive, and open coastal society. Their lives, completely dependent on the sea, shape their social, cultural, and economic characteristics. Having a strong view of the natural forces that surround their daily lives is reflected in their interaction with the sea and their extraordinary diving skills.

Through interviews and observations, including diving competitions held in Wakatobi Regency, it was revealed that the Bajo people, especially those aged 20-30 years, can dive for an average of 3-10 minutes in deep water. This data provides an overview of their extraordinary breath-holding ability. Although Abrahamsson and Schagatay (2014) noted that the longest time recorded underwater was three minutes and one second, other studies show greater variation. For example, the study by Oetama et al. (2019) also reported that the Bajau people can dive by holding their breath for 13 minutes and reach depths of up to 70 meters. Furthermore, Schagatay (2014) highlighted Stéphane Mifsud's static apnea record of 11 minutes 35 seconds, which shows the extraordinary potential of humans to hold their breath. Research on the diving abilities of the Bajo people not only provides valuable insights into human adaptation to extreme environments but also has the potential to contribute to the development of safer and more efficient diving techniques. In addition, this research also plays a role in efforts to preserve the culture and traditional knowledge of maritime communities.

The Bajo people, especially those aged 20-30 years, can dive for an average of 3-10 minutes in water. This data provides an overview of their extraordinary breath-holding ability. Measurements of the water depth reached by the Bajo people when diving often use "depa," which is the span of both arms outstretched, where one fat is, on average, around 1.5 meters. Based on information from the Bajo people, the depth they reach when diving is around 30 meters below sea level. However, it is important to note that previous studies have shown variations in the depths reached by Bajo divers. For example, research by Ariando and Arunotai (2022) noted that the Bajau people are skilled at holding their breath, with depths of around 6-10 meters. Other studies by Ilardo et al. (2018) and Maulidyna et al. (2021) prove that some Bajo divers can reach more than 70 meters of diving depths. Abrahamsson and Schagatay (2014) also reported that two divers aged 30 and 32 reached depths of up to 25 meters. Finally, Oetama et al., (2019) found that Bajo divers often dive to depths 20-30 meters.

For comparison, Schagatay (2014) recorded a scuba diving record by Nitsch in 2012, reaching a depth of 250 meters. However, Nitsch suffered a severe injury during a very rapid ascent, which may have been caused by decompression sickness (DCS). DCS is a common problem for divers caused by forming nitrogen bubbles in the blood or arterial gas embolism if lung air enters the bloodstream. This case highlights the risks of deep diving, even with scuba equipment. It is important to note that human free diving depths, including those performed by the Bajo Tribe, are much shallower than scuba diving. Nevertheless, the Bajo Tribe's extraordinary diving abilities remain impressive and demonstrate their unique adaptation to the marine environment using only traditional skills resulting from years of adaptation to the aquatic environment. Further research is needed to comprehensively understand the factors that influence the diving depths of the Bajo Tribe, including biological, socio-cultural, and environmental factors.



## ***Assistive tools used, characteristics of skilled divers, and agreed rules while diving***

The tools used by the Bajo people when diving are relatively simple and traditional, but their functions are still well maintained. Starting from swimming goggles made of wooden edges, the glass made of used house glass, and the rope made of tyre rubber. Then, they used arrows made of wood, a bow made of iron, rubber made of stainless steel, a spear handle made of wood, and a tip made of iron. In addition, wear underwear or regular pants and do not wear swimming fins. These results are also not different from the ideas of Schagatay et al. (2011), Abrahamsson and Schagatay (2014), and Rubama et al. (2024), where the equipment used during diving, often only wooden goggles for fishing and simple spears, and no fins or diving suits are used. While for modern divers such as scuba-diving, Kainde et al. (2022) explained that the sports activity uses diving equipment and is one of the high-risk sports because it uses equipment such as regulators, snorkels, BCDs, scuba tanks, weights, fins, boots, dive comps, masks, and gloves (Risfandi et al., 2024).

Aids can be used in the preparation and training process and regeneration of the diving abilities of the Bajo people, namely the preparation that is carried out first, namely seeing courage and regulating breathing so as not to rush to dive. After that, parents or friends teach children to jump into shallow or deep seas. After being able to jump and be released, follow the parents back to dive into the sea. If you are not strong enough, immediately release yourself to return to the sea's surface to take a breath, then try diving again. According to Schagatay (2014), divers can voluntarily open the eustachian tube, which connects the middle ear to the nasopharynx. With shallow depths, this method can be learned by most people with some training; otherwise, air from the lungs can be expelled through the closed nose, as most people do spontaneously. In addition, according to Maulidyna et al. (2021), another uniqueness of the Bajo tribe is that they have a certain culture when going to sea, observing the weather, and educating their children to become tough sailors.

Several rules are agreed upon when diving; namely, if there is a strong wind from the east between 7 and 9, it is advisable not to dive. Then, before going to sea, they follow customs such as throwing away betel and alcohol; the aim is to notify the ruler of the sea; this is done if diving or going to sea for a long time or far away. Furthermore, for example, 7 days after someone dies, they usually slaughter a goat; this is strictly prohibited if people go to sea; when diving or going to sea, they are not allowed to curse, say rude words, say dirty words, and litter in the sea. In line with what Maulidyna et al. (2021) passed down orally from their ancestors, there are rules or prohibitions in the form of things that should not be done. Including not littering or throwing garbage into the sea, such as wastewater from washing rice or sea cucumbers, used charcoal from cooking, coffee grounds, chilli water and ginger juice, orange peel and juice, kitchen ash or charcoal, and cigarette butts or ashes. The traditions or local wisdom mentioned earlier are taboo for the Bajo people, who have a noble goal: to preserve the sea because they live and reside there.

## **Conclusions**

This study successfully investigated the diving abilities of the Bajo people in Wakatobi Regency, Indonesia, focusing on human factors that influence their abilities. Through qualitative research methods, including interviews with informants and direct observation, it was found that diving abilities are influenced by several factors such as age, smoking habits, health conditions (including ear and nose problems, muscle cramps, and stomach ulcers), and possible genetic predisposition. The Bajo people employ a unique diving technique that combines freestyle leg movements and breaststroke arm movements, often starting the dive in a feet-first position. Their breathing technique involves holding the breath with a gradual release only when necessary, which triggers an immediate rise to the surface. Although dive durations vary, individuals in their 20s and 30s report an average underwater time of 3-10 minutes, reaching depths of 15 to over 30 meters, often measured in fathoms.

Diving preparation and training are informal, starting early through observation, practice, and traditional activities such as retrieving objects from the seabed. Regeneration of diving skills is passed down from generation to generation, with parents and elders guiding younger individuals. The minimal equipment the Bajo people use consists of wooden glasses, spears, and simple clothing. Skilled divers are identified based on strength, speed, physique (including darker skin and naturally lighter hair), and



overall diving proficiency. Several agreed rules and taboos apply, including restrictions during certain weather conditions and prohibiting inappropriate behavior at sea. This research also highlights the significant influence of the marine environment and socio-cultural practices on the extraordinary diving abilities of the Bajo people, differentiating their traditional methods from today's modern diving practices and equipment.

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