Introduction

The diets of developing countries are shifting rapidly, and overweight and obesity have emerged as major public health problems in some of these countries (Popkin and Gordon-Larsen, 2004). In 2016, the prevalence of obesity exceeded 20% in several Polynesian and Micronesian countries (NCD Risk Factor Collaboration, 2017), and the World Health Organization (WHO) (2018) reported that noncommunicable diseases (NCDs), including cardiovascular diseases and diabetes, account for an estimated 75% of all deaths in the Federated States of Micronesia (FSM).

The FSM is composed of approximately 600 small islands lying just above the equator in the Western Pacific, and consists of four states (Yap, Chuuk, Pohnpei, and Kosrae; Fig. 1). Pohnpei State (population 36,196 as of the 2010 census; Government of the Federated States of Micronesia, 2014) consists of the main island, Pohnpei Island, and eight smaller outer islands, including Pingelap Atoll.

Before the 1950s, the people of the FSM ate a traditional diet based on staple starchy crops and marine resources (Murai, 1954). After the United States Department of Agriculture started a supplementary feeding program in the 1960s, the traditional diet began to be replaced by a modern diet rich in rice, wheat flour, sugar, and other imported
or processed foods (Englberger et al., 2003). This change accelerated after a Compact of Free Association was signed between the FSM and the United States in 1986, guided by the Migration, Remittance, Aid, and Bureaucracy economy (Hezel, 2004). Since then, the FSM has faced serious public health problems, such as obesity, diabetes mellitus, hypertension, cardiac disease, and vitamin A deficiency on Pohnpei Island (Yamamura et al., 2004; Matsumoto et al., 2012). Therefore, the government, non-governmental organizations, and researchers have attempted to promote a return to the consumption of local foods because they are higher in carotenoids and vitamins than are modern foods (Englberger et al., 2009).

Several surveys of food consumption by the people of the FSM were conducted in the 2000s to reveal the dietary patterns, including: a 7-day Food Frequency Questionnaire (7-day FFQ) on Pohnpei Island from January to March 2004 (Corsi et al., 2008), and again in 2005 and 2007 (Kaufer, 2008); on Pohnpei, Mokil, and Pingelap islands in September 2008 (Kawai et al., 2010); and on Yap, Falalop, and Fais islands in November 2008 (Kawai et al., 2011). However, these studies targeted a very short term time period; Murai (1954), who surveyed the diet of one household on Udot Island, Chuuk Atoll, for 8 days from June to October 1951, pointed out the importance of studying dietary patterns over a full year. In the 2010s, a 12-month food consumption survey was conducted on Piis-Paneu Island, Chuuk State, from September 2012 to August 2013 (Yamamoto et al., 2015a), and an 18-month survey was conducted on Pingelap Island from August 2012 to January 2014 (Yamamoto et al., 2015b); these were notable as food consumption surveys conducted over a period ≥ 1 year. That said, annual fluctuations in food consumption have not been monitored. Thereafter, Yamamoto (2018) conducted a 5-year food consumption survey on Piis-Paneu Island during the years 2013-2017, to reveal annual fluctuations in food consumption. The present study gathered data on household food consumption at every meal for about 4 years to understand the long-term food behavior on Pingelap Island by comparison with several reports, including the data for Piis-Paneu Island, which is of a similar size and population to Pingelap Island.

II Study Site and Data Collection

Pingelap Atoll has three islets, Pingelap, Deke, and Sukoru islands, which have a total area of 1.8 km². Of the three, only Pingelap Island is inhabited and the inhabitable area extends from the shoreline to a patch of mueiāng (Cyrtosperma merkusii) at the center of the island (Fig. 1). The atoll has a tropical climate, with relatively warm temperatures
(average annual temperature 27～28°C; National Oceanic and Atmospheric Administration [NOAA]) and plenty of rain throughout the year (average annual precipitation 4,110 mm; Anthony, 1996).

Pingelap Atoll is about 270 km from Pohnpei Island, the center of Pohnpei State and site of the capital city Kolonia, and about 120 km from the nearest inhabited atoll, Mokil Atoll. There is a 300 m airstrip on Pingelap Island, and Caroline Islands Air flies a light aircraft to the island, but flight schedules are irregular and the price of a one-way ticket is USD 190 (in August 2018), which is expensive for the islanders. The government operates a ship that connects the outer islands in Pohnpei State with Pohnpei Island, and it costs approximately USD 15 per person, a reasonable price compared with the airfare, to travel from Pohnpei Island to Pingelap Island. However, the ship visits the island only a few times a year. The access to Pingelap Atoll is very limited.
There are about 58 households on Pingelap Island, which had a population of 239 and an average income of USD 3,000 per year in 2012 (Yamamoto et al., 2015b). One household was selected to survey dietary patterns, based on the average family size and income. Questionnaires were distributed to explore the foods consumed at every meal, including starchy staples (rice, wheat flour, breadfruit, banana, mweiang, and others), marine resources (fresh fish, dried fish, canned fish, and others), meat (fresh and canned), and others (instant noodles, fruit, and vegetables). The frequency of consumption of each item per month was calculated as follows: Frequency (%) = (total number of meals at which an item was consumed/total number of meals in 1 month) × 100. Data on food consumption were collected from February 2014 to May 2015 and May 2016 to July 2018 (total 43 months).

III Results and Discussion

1. Starchy staples

Figure 2 shows the frequency of consumption of starchy staples. The frequency of consumption of imported rice fluctuated widely monthly, ranging from 3.3% to 87.8% during the survey period. The frequency of the consumption of imported wheat flour (such as donuts, pancakes, muffins, etc. made by the household) ranged from 0.0% (in May 2014 and August 2016 only) to 26.2% per month. The household preferred to eat rice over dishes made from wheat flour. Table 1 shows the annual average frequency of consumption of particular foods during 2013-2018 (May to April is regarded as one year in the dataset). The frequency of consuming rice and wheat flour did not fluctuate greatly annually, suggesting that the monthly variation in the consumption of these commodities was much greater than the annual variation. The availability of rice and wheat flour on the island (sometimes there was none in the stores) and cash income both affected their consumption.

The frequency of breadfruit consumption ranged from 0.0% (in March and June 2018) to 58.1% per month. Breadfruit is available seasonally and its harvest time varies slightly from year to year, so the frequency of its consumption fluctuated. The household sometimes consumed preserved breadfruit (mar) during the off-season. The frequency of banana consumption ranged from 15.1 to 70.0% per month, and the household ate banana in all months during the survey period. The frequency of mweiang (C. merkusii) consumption ranged from 0.0% (in June 2014) to 39.1% per month.

The frequency of the consumption of local starchy staples did not fluctuate greatly.
Fig. 2. Frequency (%) of consumption of starchy staples (rice, wheat flour, breadfruit, banana, and mweiang [Cyrtosperma merkusii]) by one household on Pingelap Island from Feb. 2014 to May 2015 and May 2016 to Jul. 2018.
annually (Table 1); the 4-year average was highest for banana (37.4%), followed by breadfruit (19.9%), and *mweiang* (16.3%). Of the local starchy staples, banana was consumed most frequently on Pingelap Island from a long-term perspective. In Micronesia, the importance of breadfruit is often emphasized, especially in Chuuk State (Sudo, 1983). However, Yamamoto et al. (2015a) noted that the fast growth and stable production of banana year-round supports subsistence on a small island in Chuuk State (or Micronesia), which agrees with my results.

Each starchy staple complemented the others. For example, when the rice consumption decreased, the consumption of breadfruit (in May 2014, February 2015, and August 2016), banana (October to December 2014 and in March 2015), and *mweiang* (April to May 2015) increased (Fig. 2).

Comparing my results (4-year averages: rice 47.4%, wheat flour 12.5%, breadfruit 19.9%, banana 37.4%, and *mweiang* 16.3%) with a study conducted on Pohnpei Island,
Corsi et al. (2008) reported the starch consumption (days/week) in 2004 (7-day FFQ, 1 count/day) consisted of imported rice (6.5 ± 1.4), imported wheat flour products (3.5 ± 2.6), breadfruit (2.8 ± 2.2), banana (2.9 ± 2.3), and giant swamp taro (C. merkusii) (0.5 ± 1.0). Kaufer (2008) reported results (days/week) for 2005 and 2007 (7-day FFQ, 1 count/day): imported rice 6.8 and 6.1, imported flour products 4.1 and 5.0, breadfruit 4.0 and 3.8, banana (white-fleshed) 2.9 and 2.9, and taro and giant swamp taro 0.2 and 0.9, respectively. Although it is difficult to compare these results with my results, as they did not survey every meal, the frequency of consumption of rice, wheat flour, breadfruit, banana, and mweiang on Pingelap Island were 1/2, 1/5–1/4, 1/3–1/2, almost the same, and several times the respective consumption on Pohnpei Island. Far less imported rice and wheat flour products was consumed on Pingelap Island than on Pohnpei Island. Less breadfruit was also consumed on Pingelap Island than on Pohnpei Island. One reason is the difference in the survey period (season) between my study and previous reports and the fact that breadfruit is available in stores throughout almost the entire year on Pohnpei Island due to several factors (various varieties, higher production, and it is a much bigger, higher island than Pingelap Island). Conversely, much more mweiang was consumed on Pingelap Island than on Pohnpei Island. Kawai et al. (2010) also noted that the daily consumption of mweiang was significantly higher on Pingelap Island than on Pohnpei Island in September 2008. It is believed that mweiang is a more important starchy staple on a small, remote island, as compared to the situation in a bigger, modernized island.

Yamamoto (2018) found that the 5-year average frequency of consumption of rice, breadfruit, banana, and puna (C. merkusii) were 94.5, 27.5, 26.5, and 12.7%, respectively, on Piis-Paneu Island, which is the inhabited island most distant from Weno Island (the capital and commercial center of Chuuk State) in Chuuk Atoll. Much more imported rice was consumed on Piis-Paneu Island than on Pingelap Island. It takes 1 hour to travel from Piis-Paneu Island to the main island of Chuuk, Weno Island, by small boat with an outboard motor, whereas access from Pingelap Island to the main island of Pohnpei is very limited. Therefore, it is much more difficult for the people of Pingelap Island to access imported food sold on the main island of the State.

2. Marine resources

The frequency of consumption of marine resources did not fluctuate greatly monthly or annually (Fig. 3); the 4-year average was highest for fresh fish (69.9%), followed by other marine resources (1.3%), imported canned fish (1.0%), and dried fish (0.5%).
Yamamoto (2018) reported that the 5-year average frequency of consumption of fresh fish, other marine resources, canned fish, and dried fish were 78.9, 8.8, 19.6, and 36.6% respectively, on Piis-Paneu Island. By contrast, the household on Pingelap Island depended mainly on fresh fish (raw [sashimi], grilled, fried, or as soup) and rarely consumed dried fish, other marine resources, or canned fish (roughly once a month). Other marine resources were eaten occasionally, such as land crabs and sea turtles.

According to Corsi et al. (2008), the frequency of consumption of local fish and seafood and imported fish and seafood (mainly canned fish) on Pohnpei Island in 2004 were 4.8 ± 2.3 and 2.4 ± 1.9 days/week, respectively. Kaufer (2008) also reported the consumption of marine resources on Pohnpei Island in 2005 and 2007: local fish 3.9 and 4.2 days/week and imported fish 2.4 and 2.7 days/week, respectively. This indicates that the
consumption of local marine resources was greater on Pingelap Island than on Pohnpei Island. By contrast, the consumption of canned (imported) fish on Pingelap Island was much lower than on Pohnpei Island.

3. Meat and other items

The frequency of consumption of meat items also did not fluctuate greatly monthly or annually (Fig. 4); the 4-year average was highest for local fresh meat (2.3%), followed by imported canned meat (0.7%), and imported fresh meat (0.1%). The frequency of meat consumption, whether local or imported, was much lower than that of marine resources on Pingelap Island. Local animals, such as pigs and poultry, and imported turkey were seldom consumed. Yamamoto (2018) reported that the 5-year

![Graphs of meat consumption]

Fig. 4. Frequency (%) of consumption of fresh meat, canned meat, and instant noodles by one household on Pingelap Island from Feb. 2014 to May 2015 and May 2016 to Jul. 2018.
average frequency of consumption of local fresh meat, canned meat, and imported fresh meat were 1.1, 0.2, and 14.9%, respectively, on Piis-Paneu Island. Local meat and imported meat were consumed 1.3 ± 1.6 and 1.9 ± 2.1 days/week, respectively, on Pohnpei Island in 2004 (Corsi et al., 2008), 1.5 and 1.7 days/week in 2005, and 1.1 and 2.6 days/week in 2007 (Kaufer, 2008). The total consumption of meat on Pingelap Island was much lower than on Pohnpei and Piis-Paneu islands, and the main source of protein on Pingelap Island was fresh fish.

Instant noodles are popular in Micronesia, and the annual frequency of the consumption of imported instant noodles ranged from 1.1% to 36.6% (4-year average 17.9%) on Pingelap Island (Table 1), which was half that on Piis-Paneu Island (5-year average 33.6%). Although the household consumed imported instant noodles more often than canned fish and meat, the frequency of the consumption of instant noodles was low compared with Piis-Paneu Island (and probably Pohnpei Island). Fruit (ripe banana, ripe Pandanus spp., ripe papaya, Syzygium spp., etc.) and vegetables (leaves of Alternanthera sissoo, Cnidoscolus chayamansa, etc.) were rarely consumed during the survey period. Therefore, these items are not shown in the figures or tables. However, fruit is eaten not only at meals but also on other occasions, e.g., while working on the land or fishing, during meetings, while chatting, etc.; therefore, the real consumption of fruit is likely to be higher. Moreover, it is possible that the household did not mention vegetables on the questionnaire because of the small amounts of vegetables used. Long-term participant observation on the island is needed for a detailed survey of the consumption of fruit and vegetables.

IV Conclusions

This study revealed that the household in Pingelap Island was somewhat dependent on imported starchy staples, especially rice. However, the additional value of the 4-year average frequency was 60.7% for imported starchy staples and 73.6% for local starchy crops, which indicates that the household still relied on local starchy crops for more than half of the total frequency of starchy staples consumed. Imported canned fish and meat were rarely consumed and fish obtained locally was the main source of protein on Pingelap Island. Although the household consumed imported instant noodles, it did so infrequently. The dietary pattern on Pingelap Island during the 4-year survey period was traditional compared with that on Pohnpei Island. However, when I visited Pingelap Island in August 2018, the villagers said that the government would have one more ship
connecting islands of Pohnpei State in the near future and they hoped that ships would come to the island more frequently. If so, it is possible that more imported food will be consumed on the island. An inventory survey of quantitative and qualitative food behavior and related health conditions is needed to analyze public health problems in the FSM comprehensively.

Acknowledgments

I thank the Traditional Leader, Mayor, and all of the villagers of Pingelap Municipality for supporting my research on the island. In particular, I am grateful to Mr. Kodaro Soaz and his family for their generous hospitality, kindness, and openness. This study was partly supported by the Japan Society for the Promotion of Science (No. 24402006 and 16H03314).

References

Anthony, S. S. 1996. Hydrogeology and Ground-Water Resources of Pingelap Island, Pingelap Atoll, State of Pohnpei, Federated States of Micronesia. U.S. Geological Survey, Water-Resources Investigations Report 92-4005. https://doi.org/10.3133/wri924005 (last accessed April 2019)

Corsi, A., Englberger, L., Flores, R., Lorens, A. and Fitzgerald, M. H. 2008. A participatory assessment of dietary patterns and food behavior in Pohnpei, Federated States of Micronesia. Asia Pacific Journal of Clinical Nutrition 17: 309-316.

Englberger, L., Marks, G. C. and Fitzgerald, M. H. 2003. Insights on food and nutrition in the Federated States of Micronesia: A review of the literature. Public Health Nutrition 61: 5-17.

Englberger, L., Schierle, J., Hofmann, P., Lorens, A., Albert, K., Levendusky, A., Paul, Y., Lickaneth, E., Elymore, A., Maddison, M., Debrum, I., Nemra, J., Alfred, J., Vander Velde, N. and Kraemer, K. 2009. Carotenoid and vitamin content of Micronesian atoll foods: Pandanus (Pandanus tectorius) and garlic pear (Crataeva speciosa) fruit. Journal of Food Composition and Analysis 22: 1-8.

Government of the Federated States of Micronesia. 2014. Household Income and Expenditure Survey 2013/14 Main Analysis Report. Statistic Division, Office of Statistics, Budget and Economic Management, Overseas Development Assistance and Compact Management, Government of the Federated States of Micronesia, Pohnpei, FSM.
Hezel, F. X. 2004. Health in Micronesia: Over the Years. *Micronesian Counselor Issue* 53. Micronesian Seminar, Pohnpei, FSM.

Kaufer, L. 2008. *Evaluation of a Traditional Food for Health Intervention in Pohnpe, Federated States of Micronesia*. Thesis, McGill University, Montreal, Canada.

Kawai, K., Kuwahara, S., Onjo, M., Noda, S., Nishimura, A., Tominaga, S. and Nagashima, S. 2010. The influence of environmental changes on the Micronesian area: A case study of islands in Pohnpei State, Federated States of Micronesia. *South Pacific Studies* 30(2): 23-43.

Kawai, K., Kuwahara, S., Terada, R., Tominaga, S., Noda, S. and Nagashima, S. 2011. Influence of environmental changes on the Micronesian region: Case study of islands in the Yap State, Federated States of Micronesia. *South Pacific Studies* 31(2): 57-70.

Matsumoto, K., Seguchi, H., Taniguchi, H., Hada, S., Seguchi, T., Nishida, M., Suastika, K., Gde Budhiarta, A. A. and Kajiwara, N. 2012. Health and nutritional status in the village of island of Pohnpei, Federated States of Micronesia: Preliminary survey in 2009. *Bulletin of the Faculty of Health and Welfare, Kobe Women’s University* 4: 47-55. (in Japanese with an English summary)

Murai, M. 1954. Nutrition study in Micronesia. *Atoll Research Bulletin* 27: 1-239.

National Oceanic and Atmospheric Administration (NOAA). *Climate Data Online*. https://www.ncdc.noaa.gov/ (last accessed October 2018)

NCD Risk Factor Collaboration. 2017. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. *Lancet* 390: 2627-2642.

Popkin, B. M. and Gordon-Larsen, P. 2004. The nutrition transition: Worldwide obesity dynamics and their determinants. *International Journal of Obesity* 28: S2-S9.

Sudo, K. 1983. Breadfruit in Chuuk. *Kikan Minzokugaku* 7(1): 60-66. (in Japanese)

World Health Organization (WHO). 2018. *Noncommunicable diseases country profiles 2018*. http://www.who.int/iris/handle/10665/274512 (last accessed April 2019)

Yamamoto, S. 2018. Long-term food consumption survey on Piis-Paneu Island, Chuuk State, the Federated States of Micronesia. *The Journal of Island Studies* 19(2): 115-126.

Yamamoto, S., Kawanishi, M. and Nishimura, S. 2015a. Dietary patterns and food consumption in the Federated States of Micronesia: A case study conducted on Piis-Paneu Island, Chuuk Atoll, Chuuk State. *Tropical Agriculture and Development* 59(4): 170-178.
Yamamoto, S., Kawanishi, M. and Nishimura, S. 2015b. Dietary patterns and food consumption survey in the Federated States of Micronesia: A case study in Pingelap Island, Pohnpei State. *Tropical Agriculture and Development* 59(4): 161-169.

Yamamura, C. M., Sullivan, K. M., van der Haar, F., Auerbach, S. B. and Iohp, K. K. 2004. Risk factors for vitamin A deficiency among preschool aged children in Pohnpei, Federated States of Micronesia. *Journal of Tropical Pediatrics* 50: 16-19.
Long-Term Survey of Food Consumption on Pingelap Island, Pohnpei State, the Federated States of Micronesia

YAMAMOTO Sota
(Kagoshima University)

keywords: banana, breadfruit, Cyrtosperma merkusii, ethnobotany, imported food, remote island

A 4-year food consumption survey of one household at every meal was conducted on Pingelap Island, Pohnpei State, the Federated States of Micronesia, to understand food behavior over a long period. The 4-year average of the frequency of consumption of starchy staples was highest for imported rice (47.4%), followed by banana (37.4%), breadfruit (19.9%), mweiang (Cyrtosperma merkusii) (16.3%), and imported wheat flour (12.5%). The monthly variation in the consumption of rice and wheat flour was much greater than the annual variation. The household ate banana in all months during the survey period and banana was the most frequently consumed local starchy staple on Pingelap Island, suggesting that banana supports subsistence on this small, remote island throughout the year. The additional value of the 4-year average frequency was 60.7% for imported starchy staples and 73.6% for local starchy crops, indicating that the household still relied on local starchy crops for more than half of the total starchy staples consumed by frequency. Among marine resources, the 4-year average was highest for fresh fish (69.9%), followed by other marine resources (1.3%), imported canned fish (1.0%), and dried fish (0.5%). Regarding meat, the 4-year average was highest for local fresh meat (2.3%), followed by imported canned meat (0.7%), and imported fresh meat (0.1%). These results suggest that the main source of protein on the island is fresh fish caught locally. The frequency of the consumption of imported instant noodles was low. The dietary pattern on Pingelap Island was still traditional compared with Pohnpei Island, probably due to the very limited access from Pingelap Island to the main island of Pohnpei where imported food products are abundant.