

# Preliminary study about dietary intake of Tigray farmers in the southern Kilite Awlaelo district of northern Ethiopia

Masahiro HIRATA<sup>\*1)</sup>, Toshitaka MORI<sup>1)</sup>, Birhane Gebreanenia GEBREMEDHIN<sup>2)</sup>,  
Shunji ONIKI<sup>3)</sup>, Koichi TAKENAKA<sup>3)</sup>

**Abstract:** Due to the expansion of prohibited grazing and protected forest land led by local governments and/or social changes, the rangeland for livestock kept by local farmers has diminished, and consequently the number of livestock has decreased in the Eastern Zone of the Tigray Region, northern Ethiopia. It can be deduced that the decrease in livestock numbers decreases the nutrient intake of local farmers. The purpose of this paper is to conduct the preliminary study for 1) understanding the current dietary intake and characteristics of the Tigray farmer, and 2) evaluating how current local governmental policy and social changes affect their dietary intake and nutritional status in southern Kilite Awlaelo district in the Eastern Zone of the Tigray Region. Amounts of consumed foods of total 10 Tigray farmers in 3 households were measured using portable scale. Moreover, total other 10 local farmers aged from 49 years to 75 were interviewed to understand dietary intake, number of livestock and amount of milk production, contribution of milk products to dietary intake, and rangeland conditions around 1970. The characteristics of the dietary intake of the surveyed Tigray farmers were that they consumed a large amount of injera (*taita*) and bread (*gogo*), mainly with bean dishes (*shiro* or *shumshimo*) and chili pepper sauce (*silsa*), and seldom depended on meat, internal organs, and milk products in their daily meals. It was suggested that the intake of calories, protein, and fat tended to be insufficient in their daily meals, although these nutrients were partially replenished by special meals on the occasion of festivals and religious events. Since the growth of population, the dissemination of education, and the increase of prohibited grazing and protected forest land have caused the decreases in available feed resources, livestock numbers, milk production, and milk intake in Tigray farmers, they have faced malnutrition and other negative impacts on their health. The local government needs to implement a comprehensive policy that considers the subsistence and health of local peoples, rather than simply considering the conservation of the local natural environment.

**Keywords:** dietary intake, livestock number, milk and milk products, malnutrition, local governmental policy

## 1. Introduction

Humans engage in various activities for subsistence such as hunting and gathering, farming, animal keeping, and trade in order to obtain foods. In the case of the farmer, the structure of their subsistence and environmental utilization can be analyzed and understood by examining the contribution rate of self-sufficient crops to their dietary intake and amount of foods purchased from a local market (Coughe-nour *et al.*, 1985; Galvin *et al.*, 1994; Hirata, 2010; 2012a; 2012b). Current Tigray farmers in the Ethiopian Highlands keep a small number of cattle, bulls, and oxen for farming and cows for milking (Hirata *et al.*, 2018). The supply of milk products from cows has greatly contributed to the nutritional intake of the Tigray farmer due to the high nutritional value of raw milk and dairy products. Tigray farmers

are attempting to adopt better subsistence strategies by cultivating crops and raising livestock for more food resources.

Due to the expansion of prohibited grazing and protected forest land led by local governments since the 1990s, the rangeland for livestock kept by local farmers has diminished, and consequently the number of livestock has decreased in southern Kilite Awlaelo district in the Eastern Zone of the Tigray Region (Hirata *et al.*, 2018). It can be deduced that the decrease in livestock numbers decreases the nutrient intake of local farmers. Impacts of the decrease in livestock numbers on the farmers' subsistence can be assessed by examining the dietary intake of local farmers and comparing this with the situation in the past.

The purpose of this paper is to conduct the preliminary study for 1) understanding the current dietary intake and characteristics of the Tigray farmer, and 2) evaluating how

\*Corresponding Author: masa@obihiro.ac.jp

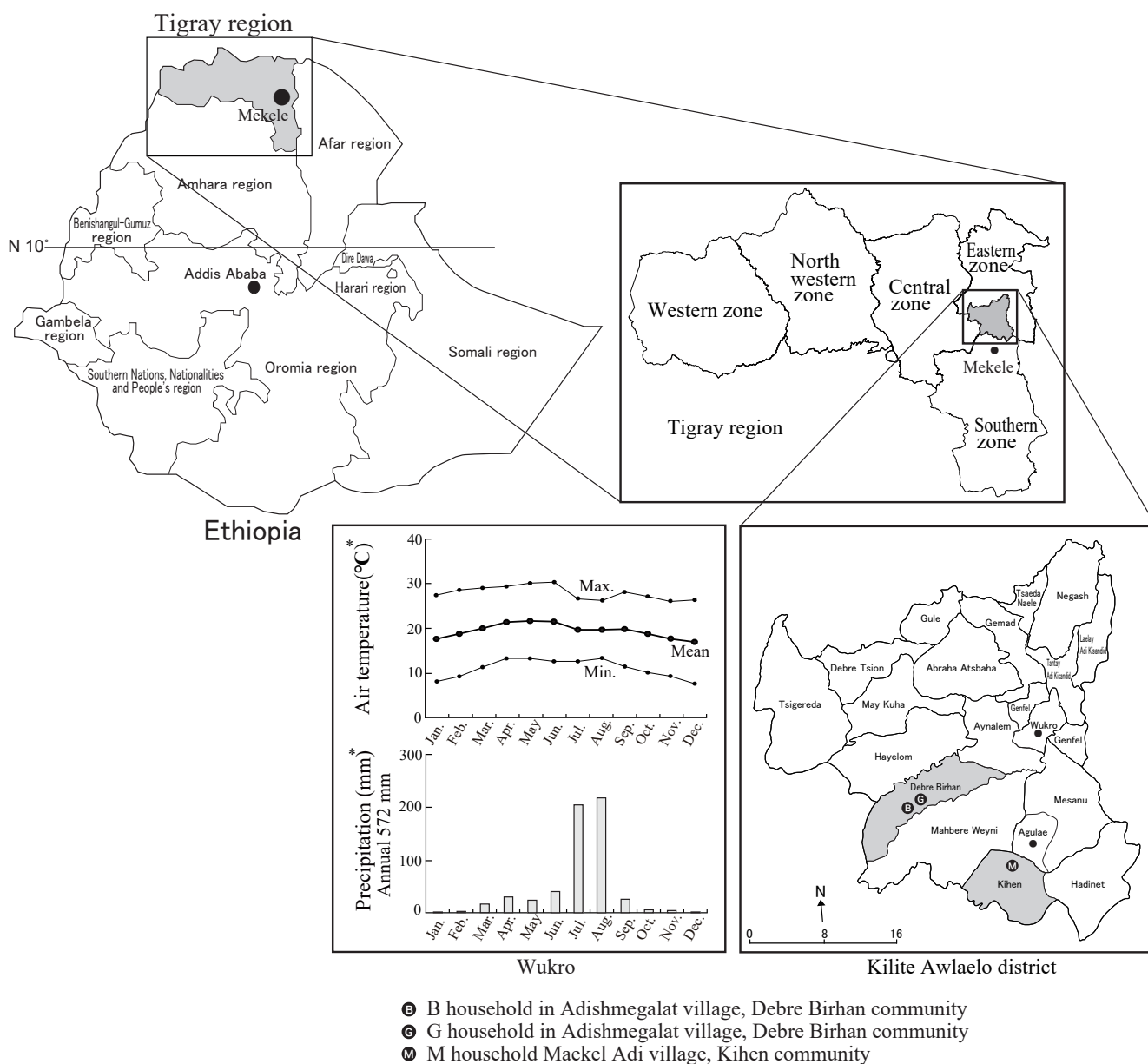
(Received, December 20th, 2019; Accepted, November 30th, 2020)

Inada-cho Nishi, Obihiro, Hokkaido 080-8555, Japan Tel: +81-155-49-5485 Fax: +81-155-49-5593

1) Obihiro University of Agriculture and Veterinary Medicine

2) College of Dryland Agriculture and Natural Resources, Mekelle University

3) Japan International Research Center for Agricultural Science



**Fig. 1. Air temperature (°C), precipitation (mm), and survey household (●) in Kilite Awlaelo district, Eastern Zone, Tigray Region in northern Ethiopia.**

\*: Air temperature and precipitation are the 22 year mean from 1992 to 2001 (National Meteorological Agency, 2012).

current local governmental policy and social changes affect their dietary intake and nutritional status in the southern part of the Kilite Awlaelo district (altitude about 2,000 m). The dietary intake was observed and its quantities measured, and additionally agricultural and pastoral history and changes in subsistence structure were retrieved from interviews with Tigray farmers.

## 2. Location and method

### 2.1. Location of study area and its natural environment

The field survey was conducted in the Debre Birhan community (*Tabia*) and Kihen community in the Kilite Awlaelo district (*Woreda*), in the Eastern Zone of the Tigray

Region in northern Ethiopia (**Figure 1**). The monthly mean air temperature of Wukro town located in the central-eastern part of the district is nearly constant throughout the year at around 20°C, due to being close to the equator. The diurnal temperature difference is much larger than the annual difference, with monthly maximum and minimum mean temperatures of approximately 30°C and 10°C, respectively. Wukro is a semi-arid region with a mean annual rainfall of 572 mm from 1992 to 2013 (National Meteorological Agency, 2014). There is large variation in rainfall between years, with 984 mm in 2000 and 305 mm due to drought in 1992. The dry season is September through June, and rainfall occurs during the rainy season of July and August, although

**Table 1. Attributes of surveyed households in Kilite Awlaelo district, Southern zone, Tigray Region.**

| Household | Community    | Surveyed person<br>(sex, age)   | Cropland<br>(ha) | Feeding animal   |                |                         |                  | Lactating animal | Surveyed period                |
|-----------|--------------|---------------------------------|------------------|------------------|----------------|-------------------------|------------------|------------------|--------------------------------|
|           |              |                                 |                  | Cattle<br>(head) | goat<br>(head) | chicken<br>(individual) | donkey<br>(head) | Cow<br>(head)    |                                |
| G         | Debre Birhan | Gk (♀45),<br>Gb (♂29)           | 2.2              | 6                | 8              | 14                      | 1                | 0                | February 28 -<br>March 2, 2015 |
| G         | Debre Birhan | Gg (♂59), Gk (♀49),<br>Gb (♂33) | 2.2              | 7                | 0              | 6                       | 1                | 1                | September 9-13,<br>2019        |
| B         | Debre Birhan | Bk (♀41),<br>Bb (♂29)           | 2.0              | 8                | 17             | 12                      | 1                | 2                | March 3-5,<br>2015             |
| M         | Kihen        | Mm (♂56), Mt (♀49),<br>Mb (♂33) | 3.5              | 7                | 0              | 8                       | 1                | 2                | September 15-19,<br>2019       |

the rainy season may linger into September. As described above, the natural environment of the study area in the Ethiopian highlands, which is close to the equator, has a warm mean temperature throughout the year, a semi-arid climate comprising rainy and dry seasons, and large variation in rainfall between years.

## 2.2. Survey households

Dietary intake of Tigray farmers were randomly surveyed at 3 households, two households (household G and household B) from Adishmegalat village (*Kushet*), Debre Birhan community and one household (household M) from Maekel Adi village, Kihen community in (Fig. 1). There are no paved roads and no public buses from Adishmegalat village to the market area of Wukro town or Agulae town. Travel takes about 3 hours on foot between them. On the other hand, it takes only 1 hour from Maekel Adi village to Agulae town along a paved road. A periodic market is held every Thursday in Wukro town and every Saturday in Agulae town.

Almost all farmers in the Kilite Awlaelo district raise livestock as well as cultivate crops. Household G had 2.2 ha<sup>A</sup> of cropland, kept 4 cattle (2 oxes and 2 cows), and 8 goats. Household B had 2.0 ha of cropland, kept 5 cattle (2 oxes and 3 cows), and 10 goats. Household M had 3.5 ha of cropland, kept 4 cattle (2 oxes and 2 cows). They cultivated barley, wheat, teff, flax and glass beans by rain fed. Household G also planted sorghum in a better soil location in years when sufficient precipitation was expected. In household G, if the precipitation was normal and crops could be harvested, two-thirds of the barley and wheat were used for the household's own consumption, and one-third was sold to fund necessary supplies. Livestock was also sold in the market according to present needs. Due to the current decrease in milk production caused by the decrease in the number of livestock, they could not at the time of the survey

produce a large volume of butter oil to sell it in the market. Household B did not sell agricultural products, and used all products for its own consumption. They sold livestock in the market to fund supplies. The household M sold remaining agricultural products in the market once it had secured its own consumption needs. Livestock was also sold in the market as needed. Household G kept 8 goats in 2015, but did not own goats in 2019. Regarding animal management, the situation necessitated selling goats and keeping cattle as much as possible due to frequent droughts and the decrease in feed resources in recent years (Hirata *et al.*, 2018). Oxen were used for farming such as plowing and thrashing, and cow for milk production. Cattle feces was used as fuel for cooking (Hirata *et al.*, 2019). Although goats used to be milked in the past, they were not milked at the time of the survey.

Dietary intake was measured in 10 total people across the 3 households (Table 1). In household G, the on-site survey followed Gk (female, 45 years old) and Gb (male, 29) from February 28 to March 2, 2015 and Gg (male, 59), Gk (female, 49), and Gb (male, 33) from September 9 to September 13, 2019. In household B, the survey followed Bk (female, 41) and Bb (male, 29) from March 3 to March 5, 2015. In household M, it followed Mm (male, 56), Mt (female, 49), and Mb (male, 33) from September 15 to September 19, 2019. Diet intake was measured in total 10 persons from the 3 households (Table 1). February and March, when the survey was conducted, was the dry season, and September was the rainy season (Fig. 1). The dry season is the time when food production is scarce and milk production from cows decreases. Household G did not milk cows in February or March 2015, but milked twice a day from one cow in the morning and evening in September 2019. The amount of milking at one time was about 900 mL/head. Household B milked once a day from two cows in the morning to obtain about 200 mL/head of milk, even

in March 2015 during the dry season. Household M milked twice a day from two cows in the morning and evening in September during the rainy season. The amount of milking at one time was about 700 mL/head.

The total number of households in the Community was estimated as 1,311 in the Debre Birhan community and 1,402 in the Kihen community, respectively (*Woreda Kilitaawlaelo Planning and Finance office, 2019a*). The mean number of cattle raised by each household was estimated as 3.0 head/household in the both communities (*Woreda Kilitaawlaelo Planning and Finance office, 2019b*). The three households surveyed in this study were standard households in the Debre Birhan and Kihen communities.

Tigray farmers are mostly Ethiopian Orthodox Christian. Ethiopian Orthodox requires fasting, and the healthy adults follow fasting practice. Older people, sick people, and children under 10 do not necessarily need to fast. Many farmers in the study areas practice fasting by consuming nothing from sunrise to noon. Meals during fasting do not include animal foods such as meat, internal organs, egg, or milk products; only vegetable-based foods such as cereals, beans, and vegetables are allowed to be consumed. Fasting occurs every Wednesday and Friday. This semiweekly fasting is called *thom dihnnet*. In addition to *thom dihnnet*, Ethiopian Orthodox sets the religious fasting periods as 55 days from February to April, 40 days from June to July, and 2 weeks in August, totaling more than 200 days annually (*Desalegn et al., 2018*). Therefore, the survey in February and March 2015 was conducted during the fasting period. On Wednesdays in September 2019 were fasting days: September 11 and September 18. Household B milked two cows in March 2015 during the fasting period. The raw milk was consumed by a 71 year old grandmother and children.

### 2.3. Methods for current dietary intake

Amounts of consumed foods of the total 10 Tigray farmers in the 3 households were measured using portable scale (AND HL-4000). The amount of consumed food was also estimated by visual measurement when they had guests or the meals were not planned in advance. The ingredients used in dishes were also weighted separately to calculate the amount of food consumed according to the types of ingredient. The calories (kcal), protein (grams), fat (grams), carbohydrates (grams), and ash (grams) of the consumed food in a day were calculated based on the food composition table (*Kagawa, 2006; Jenness and Sloan, 1970; Ishii, 1998*).

The dietary intake during the fasting period was mea-

sured across 3 days from February 28 to March 2, 2015 in household G, and in 3 days from March 3 to March 5, 2015 in household B. The dietary intake during the non-fasting period was measured across 3 days on September 9, 10, and 13, 2019 in household G, and across 4 days on September 15, 16, 17, and 19, 2019 in M household. The mean dietary intake was calculated by gender in all households. The Ethiopian New Year took place on September 12, 2019. Since the celebratory meal was prepared on the New Year, the amount of dietary intake of this meal was calculated separately. In this paper, the meals consumed during the fasting and non-fasting periods are called 'daily meal', and the meals used for the New Year and/or festivals are called 'special meal'.

### 2.4. Methods for past dietary intake

The interview was randomly conducted with a total of 10 local farmers: 7 local farmers aged from 49 years to 75 years in the Debre Birhan community and 3 local farmers aged from 59 years to 63 years in the Kihen community. Questions focused on dietary intake, number of livestock, amount of milk production and its consumption, and rangeland conditions around 1970.

## 3. Food items and dietary intake

### 3.1. Food items

**Figure 2** shows the food items consumed by Gg in household G from September 9 to September 13, 2019 and Mm in household M from September 15 to September 19, 2019. The coffee called *bunna* was drunk almost every day after a meal or when a guest visited. Raw coffee beans were roasted, crushed finely, boiled with water in front of family members and/or guests, and then consumed by everyone together. The habit of coffee drinking has become a cultural practice for the Tigray farmer. About 110 mL of coffee was poured and about 10 g of sugar added into a small cup. Since coffee was usually prepared 3 times from one use of coffee beans, a considerable amount of sugar was consumed through coffee drinking. The local beer called *sowa* was made by baking flat bread made from barley flour and/or sorghum flour, and then allowed to stand in water with malts during several days for fermentation. Households G and M previously drank *sowa* frequently after farming or after grazing. Relatives or friends often enjoyed conversing around *sowa*.

The food items using cereals as they are include *mogo*, which is boiled, and *kollo*, which is roasted on an iron plate. *Mogo* was often prepared at the beginning of each month.

| Diet variety                       | Local name         | 9 Sep.     | 10 Sep. | 11 Sep. | 12 Sep.                            | 13 Sep.    | 15 Sep. | 16 Sep. | 17 Sep. | 18 Sep. | 19 Sep. |
|------------------------------------|--------------------|------------|---------|---------|------------------------------------|------------|---------|---------|---------|---------|---------|
|                                    |                    | Normal day |         |         | Non-normal day<br>(New Year's Day) | Normal day |         |         |         |         |         |
| <b>Drinks</b>                      |                    |            |         |         |                                    |            |         |         |         |         |         |
| Coffee                             | <i>Bunna</i>       | ●          | ●       | ●       | ●                                  | ●          | ●       | ●       | ●       | ●       | ●       |
| Local beer                         | <i>Sowa</i>        | ●          | ●       | ●       | ●                                  | ●          | ●       | ●       | ●       | ●       | ●       |
| <b>Cereals</b>                     |                    |            |         |         |                                    |            |         |         |         |         |         |
| Boild cereals                      | <i>Mogo</i>        |            |         |         |                                    |            |         |         |         |         |         |
| Rosted cereals                     | <i>Kollo</i>       |            |         |         | ●                                  |            |         |         |         |         |         |
| Injera                             | <i>Taita</i>       | ●          | ●       | ●       | ●                                  | ●          | ●       | ●       | ●       | ●       | ●       |
| Fermented flat bread               | <i>Gogo</i>        | ●          | ●       | ●       | ●                                  | ●          | ●       | ●       | ●       | ●       | ●       |
| Non-fermented flat bread           | <i>Ketcha</i>      |            |         |         |                                    |            | ●       |         |         | ●       | ●       |
| <b>Milk products</b>               |                    |            |         |         |                                    |            |         |         |         |         |         |
| Raw milk                           | <i>Tsaba</i>       |            |         |         | ●                                  |            |         |         |         |         |         |
| Naturally fermented milk           | <i>Rego</i>        |            |         |         |                                    |            |         |         |         |         |         |
| Buttermilk                         | <i>Awuso</i>       |            |         |         |                                    |            |         |         |         |         |         |
| Cottage cheese                     | <i>Ajibo</i>       |            |         |         | ●                                  |            |         |         | ●       |         | ●       |
| Whey                               | <i>Mencheba</i>    |            |         |         | ●                                  |            |         |         | ●       |         | ●       |
| Mixture of milk products           | <i>Landa</i>       |            |         |         |                                    |            |         |         |         |         |         |
| Butter oil                         | <i>Sihum</i>       |            |         |         | ●                                  |            |         |         |         |         |         |
| Buttermilk with baked barley flour | <i>Hazo</i>        |            |         |         | ●                                  |            |         |         | ●       |         |         |
| <b>Dishes</b>                      |                    |            |         |         |                                    |            |         |         |         |         |         |
| Bean paste                         | <i>Shiro</i>       | ●          | ●       |         |                                    | ●          |         |         |         |         | ●       |
| Dall cuisine                       | <i>Shumshimo</i>   |            |         | ●       |                                    |            |         | ●       |         | ●       |         |
| Read papper source                 | <i>Sils</i>        | ●          | ●       | ●       | ●                                  | ●          | ●       | ●       | ●       |         | ●       |
| Meat with read papper              | <i>Keyh tsebhi</i> |            |         |         | ●                                  |            |         |         | ●       |         |         |
| Porridge                           | <i>Ga'at</i>       |            |         |         |                                    |            | ●       |         |         |         |         |
| Fried vegetables                   | <i>Alucha</i>      |            |         |         |                                    |            |         |         |         |         |         |

Fig. 2. Food items of Gg in household G, Debre Birhan community from September 9 to 13, 2019 and Mm in household M, Kihen community from September 15 to 19, 2019.

*Kollo* was used for work breaks and conversations. Injera called *taita* was made from barley flour and wheat flour, fermented flat-baked bread called *gogo* was made from wheat flour, and non-fermented flat-baked injera called *ketcha* was made from wheat flour. *Taita* and *gogo* were mainly consumed in the daily meal.

Raw milk called *tsaba* and naturally fermented milk called *regu* were rarely drank in the daily meal. *Rego* was processed into butter called *tesmi* and buttermilk called *awuso* through churning (Hirata *et al.*, 2013). Since milk production had decreased in the recent years, they often kept 3 to 4 days' worth of *regu* and then churned it. They did not eat *tesmi* for food, but applied it to hair and skin as cosmetics. Milk fat used as an ingredient was not butter, but butter oil. Butter oil called *sihum* was processed by heating butter. *Sihum* was once an indispensable ingredient as the cooking oil for the Tigray farmer, but now vegetable oil purchased from the local market became popular and conse-

quently *sihum* was used only on the New Year and religious events. They drank *awuso*, or used *awuso* as a sause called *hazo* by mixing with baked barley flour. *Awuso* was heated to process cheese called *ajibo* and whey called *mencheba*. It can be said that the milk products mainly consumed by the Tigray farmer today are *ajibo* and *mencheba*. A milk product called *landa* was made by adding raw milk to *ajibo* and *mencheba*, and *landa* was used as a sause with dishes.

The dishes consumed with *taita* and *gogo* were mainly *shiro*, which was simmered with bean powder in red pepper and vegetable oil, *shumshim*, which was simmered with coarsely ground beans in red pepper and vegetable oil, *sils*, which was simmered in red pepper and vegetable oil, and *alucha*, which was fried and stewed with vegetables, spices and vegetable oil (Figure 3). *Sils* was sometimes prepared with eggs, potatoes, and tomatoes. It was *shiro* and *sils* that were most frequently used for daily meals. *Ga'at* was also made by adding hot water to wheat flour and kneading them

together with a stick. They believed that *ga'at* was especially good for women after giving birth because of its easy digestion. The dish of meat seasoned with red pepper called *keyh tsebhi* was consumed on September 12 and September 17, 2019. September 12, 2019 was the New Year in Ethiopian calendar, and September 17 was a day of religious events involving the attendance of a banquet after a funeral. Meat and internal organs were not consumed in the daily meal, but sometimes consumed in the special meal during festivals and religious events.

It became clear, as in Fig. 2, that the daily meal of the



Fig. 3. Injera (*taita*) and bread (*gogo*) with red pepper sauce (*silsa*) and cottage cheese (*ajibo*) at lunch in household G.

Tigray farmer consisted of injera (*taita*) and bread (*gogo*) mainly as basic foods with bean dishes (*shiro* or *shumshimo*), frequently red pepper (*silsa*), cottage cheese (*ajibo*), and buttermilk (*awuso* or *hazo*) once every 3 or 4 days, and coffee (*bunna*) and local beer (*sowa*) after meals. These foods were supplemented with meat, internal organs, and more milk products in the special meal on festivals and religious events.

### 3.2. Dietary intake

Table 2 shows the mean dietary intake of males and females during the fasting period in the dry season from February to March 2015 and during the non-fasting period in the rainy season in September 2019. The mean daily caloric intake was 2,488 kcal/day for men and 2,055 kcal/day for women during the fasting period in the dry season, and 2,491 kcal/day for men and 1,712 kcal/day for women during the non-fasting period in the rainy season. The caloric intake during the non-fasting period was not greater than the fasting period. Since foods were allowed to be consumed from the afternoon onward even in the fasting period, it was suggested that the same amount of food was consumed in the afternoon as during the non-fasting period. Although Desalegn *et al.* (2018) reported that Ethiopian Orthodox fasting negatively affected maternal nutritional status and

Table 2. Mean dietary intake of males and females of surveyed households during the fasting period in the dry season and during the non-fasting period in the rainy season.

| Intake item                         | Male               |                  |              |                       |              | Female             |                  |              |                       |              |
|-------------------------------------|--------------------|------------------|--------------|-----------------------|--------------|--------------------|------------------|--------------|-----------------------|--------------|
|                                     | Energy<br>kcal (%) | Protein<br>g (%) | Fat<br>g (%) | Carbohydrate<br>g (%) | Ash<br>g (%) | Energy<br>kcal (%) | Protein<br>g (%) | Fat<br>g (%) | Carbohydrate<br>g (%) | Ash<br>g (%) |
| Dry season and fasting period       |                    |                  |              |                       |              |                    |                  |              |                       |              |
| Total diet intake                   | 2488 (100)         | 57 (100)         | 21 (100)     | 484 (100)             | 8 (100)      | 2055 (100)         | 49 (100)         | 18 (100)     | 415 (100)             | 7 (100)      |
| Self-supplied food                  | 2197 (88)          | 55 (97)          | 12 (56)      | 432 (89)              | 4 (51)       | 1771 (86)          | 47 (96)          | 10 (57)      | 363 (87)              | 3 (47)       |
| Purchased food                      | 291 (12)           | 2 (3)            | 9 (44)       | 52 (11)               | 4 (49)       | 284 (14)           | 2 (4)            | 8 (43)       | 52 (13)               | 4 (53)       |
| Self-supplied diet intake           |                    |                  |              |                       |              |                    |                  |              |                       |              |
| Meat and offal                      | 0 (0)              | 0 (0)            | 0 (0)        | 0 (0)                 | 0 (0)        | 0 (0)              | 0 (0)            | 0 (0)        | 0 (0)                 | 0 (0)        |
| Milk and milk products              | 0 (0)              | 0 (0)            | 0 (0)        | 0 (0)                 | 1 (0)        | 0 (0)              | 2 (0)            | 0 (0)        | 12 (0)                | 0 (0)        |
| Cereals                             | 1978 (80)          | 49 (86)          | 12 (55)      | 408 (84)              | 3 (33)       | 1725 (84)          | 41 (83)          | 10 (54)      | 338 (82)              | 3 (38)       |
| Beans                               | 73 (3)             | 5 (9)            | 0 (1)        | 13 (3)                | 0 (6)        | 71 (3)             | 5 (9)            | 0 (2)        | 12 (3)                | 1 (8)        |
| Rainy season and non-fasting period |                    |                  |              |                       |              |                    |                  |              |                       |              |
| Total diet intake                   | 2491 (100)         | 61 (100)         | 31 (100)     | 441 (100)             | 11 (100)     | 1712 (100)         | 41 (100)         | 23 (100)     | 315 (100)             | 9 (100)      |
| Self-supplied food                  | 2083 (84)          | 56 (92)          | 15 (47)      | 386 (88)              | 4 (38)       | 1280 (75)          | 36 (87)          | 10 (42)      | 245 (78)              | 3 (29)       |
| Purchased food                      | 408 (16)           | 5 (8)            | 17 (53)      | 54 (12)               | 7 (63)       | 431 (25)           | 5 (13)           | 14 (58)      | 70 (22)               | 7 (71)       |
| Self-supplied diet intake           |                    |                  |              |                       |              |                    |                  |              |                       |              |
| Meat and offal                      | 25 (1)             | 2 (3)            | 2 (6)        | 0 (0)                 | 0 (1)        | 28 (2)             | 2 (5)            | 2 (8)        | 0 (0)                 | 0 (1)        |
| Milk and milk products              | 40 (2)             | 4 (7)            | 2 (7)        | 1 (0)                 | 0 (4)        | 20 (1)             | 2 (5)            | 1 (4)        | 0 (0)                 | 0 (2)        |
| Cereals                             | 1946 (78)          | 45 (74)          | 10 (33)      | 374 (85)              | 3 (28)       | 1158 (68)          | 27 (67)          | 6 (27)       | 231 (73)              | 2 (20)       |
| Beans                               | 67 (3)             | 4 (7)            | 0 (1)        | 12 (3)                | 1 (5)        | 53 (3)             | 4 (9)            | 0 (1)        | 9 (3)                 | 0 (5)        |

**Table 3. Mean dietary intake of males and females of surveyed households in New Year's Day 12 September on, 2019.**

| Intake item               | Male       |           |           |              |          | Female     |          |          |              |          |
|---------------------------|------------|-----------|-----------|--------------|----------|------------|----------|----------|--------------|----------|
|                           | Energy     | Protein   | Fat       | Carbohydrate | Ash      | Energy     | Protein  | Fat      | Carbohydrate | Ash      |
|                           | kcal (%)   | g (%)     | g (%)     | g (%)        | g (%)    | kcal (%)   | g (%)    | g (%)    | g (%)        | g (%)    |
| Total diet intake         | 3281 (100) | 105 (100) | 110 (100) | 384 (100)    | 14 (100) | 2355 (100) | 76 (100) | 91 (100) | 272 (100)    | 11 (100) |
| Self-supplied food        | 2746 (84)  | 98 (94)   | 91 (83)   | 314 (82)     | 8 (59)   | 1960 (83)  | 71 (94)  | 80 (87)  | 201 (74)     | 6 (59)   |
| Purchased food            | 535 (16)   | 6 (6)     | 19 (17)   | 69 (18)      | 6 (41)   | 396 (17)   | 5 (6)    | 11 (13)  | 70 (26)      | 4 (41)   |
| Self-supplied diet intake |            |           |           |              |          |            |          |          |              |          |
| Meat and offal            | 877 (27)   | 51 (49)   | 70 (64)   | 0 (0)        | 3 (19)   | 780 (33)   | 41 (54)  | 64 (70)  | 0 (0)        | 2 (21)   |
| Milk and milk products    | 326 (10)   | 13 (12)   | 13 (12)   | 38 (10)      | 3 (18)   | 271 (12)   | 10 (13)  | 11 (12)  | 34 (12)      | 2 (21)   |
| Cereals                   | 1498 (46)  | 30 (29)   | 7 (6)     | 271 (71)     | 3 (19)   | 880 (37)   | 18 (24)  | 4 (5)    | 164 (60)     | 2 (15)   |
| Beans                     | 29 (1)     | 2 (2)     | 0 (0)     | 5 (1)        | 0 (2)    | 20 (1)     | 1 (2)    | 0 (0)    | 3 (1)        | 0 (1)    |

dietary patterns in rural Tigray, there was no difference in the caloric intake between the fasting and non-fasting periods.

Seventy-five percent to eighty-eight percent of the caloric intake depended on self-sufficient food. This was because the caloric intake depended largely on self-sufficient cereals, whose values were 68% to 84%. These data show that the farmers ingested large amounts of *taita* and *gogo* in daily meals, and consequently *taita* and *gogo* contributed most to their dietary intake.

The mean daily caloric requirement for men aged 30 to 59.9 years with a weight of 55 kg and a high physical activity level is 3,100 kcal per day (FAO, 2004). It was suggested that the daily meal that mainly consisted of *taita* and *gogo* with *shiro/shumshimo* and *silsi* as the basic food did not meet the required caloric intake for the adult male Tigray farmers in the condition that the intense labor power was required for crop cultivating and livestock keeping such as plowing in a crop field with oxen, and milking and grazing management of animals. The mean daily caloric requirement for women aged 30 to 59.9 years with a weight of 50 kg and a normal physical activity level is 2,200 kcal per day (FAO, 2004). The adult female Tigray farmers, whose tasks in daily life were cooking, cleaning rooms and gardens, collecting animal feces and firewood as fuel, and drawing water, could also not ingest the required calories from the daily meals. On the other hand, **Table 3** shows the mean dietary intake for the New Year on September 12, 2019. The daily caloric intake was 3,281 kcal/day for men and 2,355 kcal/day in women, which exceeded the required caloric intakes. The Tigray farmer faces special meals almost every month at the New Year as well as the celebration after the religious fasting periods, and festivals and ceremonial events. It should be noted that while under this dietary intake, the caloric requirement was not obtained

in the daily meal, this was partially supplemented by the special meal at the special religious occasions.

It is generally said that Tigray farmers do not eat meat in daily meals. The results of the survey indicate that the daily caloric intake of meat and internal organs was 0 kcal/day to 28 kcal/day, and these data showed that meat and internal organs were seldomly consumed in the daily meal. During the non-fasting period, meat and internal organs were consumed on September 17, 2019, the day of the religious event. Non-consumption of meat and internal organs in daily meals was also reported in the case of Ladakh, northern India, where the population is overcrowded and there is limited rangeland with sufficient herbaceous plants (Hirata, 2010). In the case of milk products, its caloric intake was 0 kcal/day to 40 kcal/day, or 0% to 2% of the total caloric intake. It was demonstrated that the contribution of milk products to dietary intake was critically small in the daily diet of the Tigray farmer.

The mean daily protein intake was 57 g/day for men and 49 g/day for women during the fasting period in the dry season, and 61 g/day for men and 41 g/day for women during the non-fasting period in the rainy season. The daily protein requirement and the daily protein allowance<sup>B)</sup> are, respectively, 50 g/day and 60 g/day for men in their 30s to 50s, and 40 g/day and 50 g/day for women in their 40s (Kagawa, 2006). Although they ingested the required amount of protein in daily meals, the women did not meet the recommended protein intake. Wheat and barley contain around 10% protein. The Tigray women ingested the large amounts of *taita* and *gogo* made of barley flour and wheat flour in daily meals, while the protein intake was rather deficient. On the other hand, the protein intake on the New Year was 105 g/day for men and 76 g/day for women, which fully satisfied the recommended amount. This came from the increase in the take of meat, internal organs, and

milk products.

It is said that the intake of beans with cereals together, with a bean ratio of 10% to 20% of cereals, supplies the well-balanced intake of all essential amino acids (Yoshida, 2000). The dietary pattern of the surveyed households, which consumed large amounts of *taita* and *gogo* with a small number of bean dishes such as *shiro* and *shimushimo*, reflected the ideal pattern of protein intake. However, since the protein intake tended to be deficient in the daily meal, it is necessary to replenish it by consuming more meat, internal organs, and milk products.

The recommended daily fat intake<sup>B)</sup> is 20% to 25% of total caloric intake for both men and women in their 30s and 50s (Kagawa, 2006). In the case of these surveyed households, this value corresponds to 53 g/day to 66 g/day for men and 36 g/day to 55 g/day for women. Since the fat intake was 18 g/day to 31 g/day for men and women, they did not meet the criterion of fat intake. It was understood that the dietary pattern of the surveyed households, which consumed large amounts of *taita* and *gogo*, did not provide the necessary fat in the daily meal. In the New Year's diet, the fat ingested was 110 g/day for men and 76 g/day for women through consuming meat, internal organs, and milk products, which led to adequate fat intake being met. It was understood that meat, internal organs, and milk products play an important role in the diet of the Tigray farmer.

As such the characteristics of the dietary intake in the surveyed Tigray farmers were that they consumed a large amount of injera (*taita*) and bread (*gogo*), mainly with bean dishes (*shiro* or *shumshimo*) and chili pepper sauce (*silsi*), and seldom depended on meat, internal organs, and milk products in daily meals during the fasting period and non-fasting period. It was suggested that the intake of calories, protein, and fat tended to be insufficient in daily meals, while these nutrients were partially replenished by the special meal on the occasion of festivals and religious events. Although many studies have reported malnutrition as prevalent among Tigray farmers (Mulugeta *et al.*, 2009; Mulugeta *et al.*, 2010; Hailelassie *et al.*, 2013; Desalegn *et al.*, 2018), our data pointed out the importance of the special meal at festivals and religious events which partly compensated for their nutritional shortage.

#### 4. Current changes in dietary intake of the Tigray farmer

The current environmental conservation policies by the region's local government have had a major impact on the subsistence of the Tigray farmer. During the Imperial

era, which ended in 1974, the natural grassland and forest around the surveyed area were managed jointly by local neighboring communities (Hirata *et al.*, 2018). Each household kept about 20 to 30 head of cattle. Herd boys stayed with cattle together in the natural grassland and forests for a few months, and milked cows and processed raw milk into milk products. When the herd boys returned to the village with the cattle from the natural grassland and forests, they brought back a large amount of butter oil. The farmer in the Imperial era was rich both financially and nutritionally due to the cattle-derived resources. The farmer was free to convert the natural grassland or forest into cropland, and the land they cultivated became privately owned and operated.

Large areas of the natural grassland and forest remained even in the socialist era after 1975, with large areas for animals to graze around the communities. Although the numbers of livestock gradually decreased due to frequent droughts, each household kept a few dozen animals even during the socialist era, and they were able to consume dairy products such as raw milk, buttermilk, curd, and butter oil on a daily basis.

Democratization started in 1991, and the prohibited grazing and protected forest land expanded based on the government policy (Tigray Forestry Action Plan, 1996; Regional Land Use Planning Division, 2000; Nedessa and Ali, 2005; Yami *et al.*, 2013). To ensure better feed resources for oxen, areas of seasonally-closed grazing land specified voluntarily by the local communities also increased. As the result of drawing of areas of Kihen community, prohibited grazing and protected forest land, and seasonally-closed grazing land by the householder of M household in Kihen, using the Landsat-8 Operational Land Imager image, the total area of Kihen community was 94.5 km<sup>2</sup>, prohibited grazing and protected forest land was 13.2 km<sup>2</sup>, seasonally-closed grazing land was 6.0 km<sup>2</sup>. The total area of prohibited grazing and protected forest land and seasonally-closed grazing land reached 20.3% of the total area of the community. Due to population growth, they have developed the natural grassland and forests into cropland. As a consequence, the common free grazing land where grazing was allowed throughout the year decreased dramatically after the democratic era began. The numbers of livestock decreased due to the effects of droughts, expansion of cropland, reduction of the natural grassland and forests, and decreased numbers of herd boys due to school education (**Figure 4(a)**). Many households now keep only one or two oxen and one or two cows.

Based on the testimony of a 60 year old woman from the



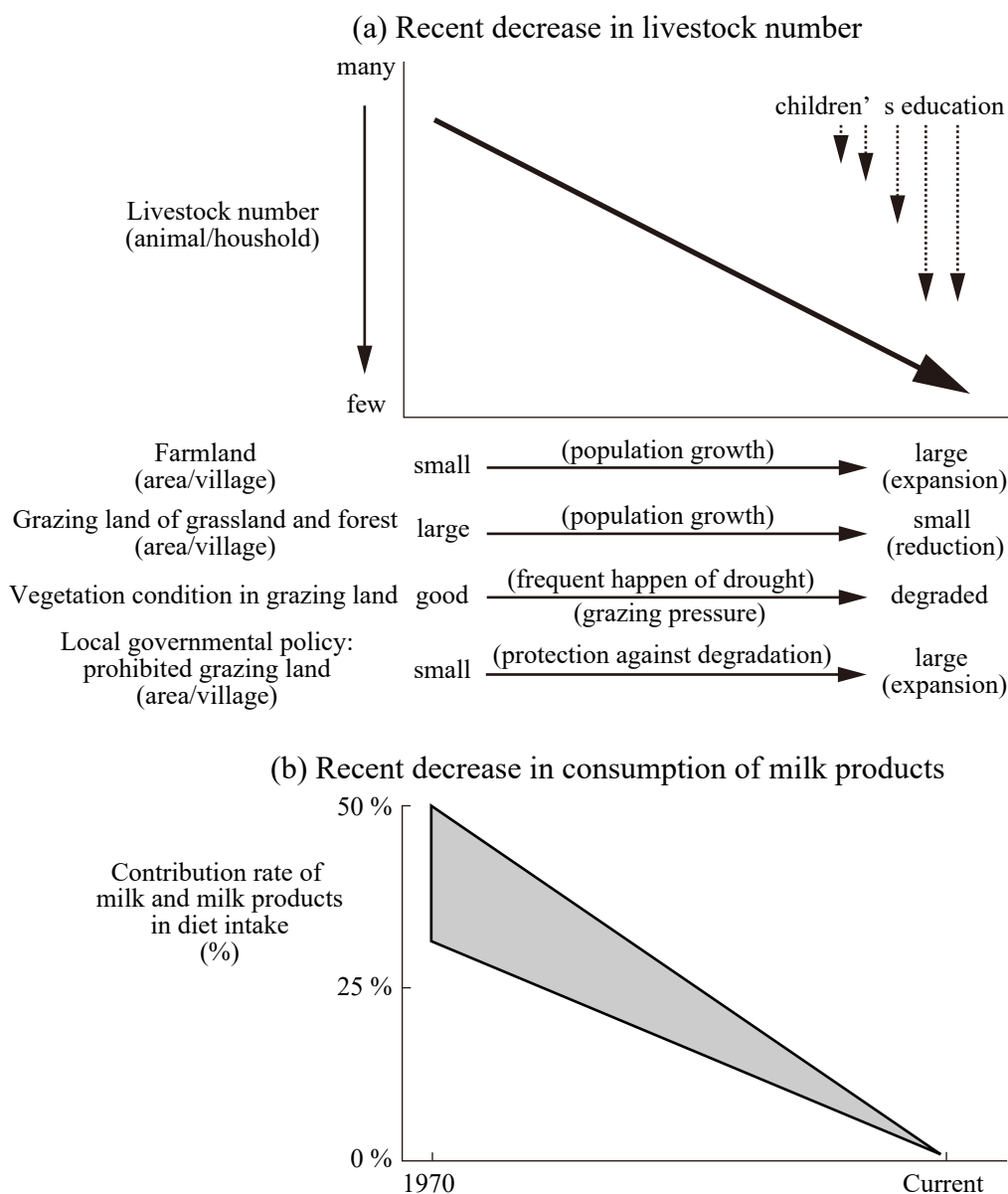


Fig. 4. Recent decrease in livestock number due to natural and social factors (a) (Hirata *et al.*, 2018), and recent decrease in consumption of milk and milk products in diet intake (b).

Debre Birhan community, in the period around 1970, each household raised around 25 cattle, and always kept 5 to 6 lactating cows. The milking amount was about 2 Ls per head. They ate injera (*taita*), bread (*gogo*), and bean dishes (*shiro* or *shumshimo*), always with cottage cheese (*ajibo*). Butter oil (*sihum*) was always used for cooking bean dishes. Milk products contributed approximately 30% to 50% to dietary intake around 1970 (Fig. 4(b)). Similar answers were obtained from 9 other interviewees. The contribution ratios of milk products into dietary intake were reported as 45% for Tuareg pastoralists in Niger (Bernus, 1988), 36% of Fulani pastoralists in Niger (Bernus, 1988), 45% of Tamasheq pastoralists in Mali (Wagenaar-Brouwer, 1985), 31% of Maasai pastoralist in Kenya (Nestel, 1986), and 31% of Borana pastoralists in Ethiopia (Galvin *et al.*, 1994). Hence, it

could be possible that the contribution ratio of dairy intake was about 30% to about 50%.

According to the testimony of a 60 year old woman from the Kihen community, the intake of milk products around 1970 was about 1 L/person/day by raw milk equivalent. One liter of raw milk per day will supply 660 kcal/L/day of energy, 6.4 g/L/day of protein, and 7.8 g/L/day of lipids (Jenness, 1999). Adding 1 liter's value of milk products to the current dietary intake could almost lead to the caloric reference intake being satisfied at a high level of physical activity, exceeding the daily protein allowance and improving lipid intake significantly. Cow's milk is a highly nutritious foodstuff that contains not only fat and high-quality protein, but also minerals and vitamins. It was presumed that the intake of milk products was once important for the

dietary intake of the Tigray farmer. The current intake of milk products in the surveyed households was 0 to 40 kcal/day in daily meals. This was mainly due to the fact that fresh raw milk, sour milk, and butter oil were rarely consumed in daily meals, and cottage cheese and whey could be only consumed every 3 or 4 days due to the decrease in milk production. The number of cattle raised by the surveyed households was 6 to 8. According to a questionnaire survey of 22 households in 2016 and 2017, the number of cattle raised was 0 to 8, including 0 to 3 cows (Hirata *et al.*, 2018). It was considered that the decrease in the livestock number and the intake of milk products was the tendency not only in the surveyed households, but also in the surrounding area.

Hence, since the population increase, the dissemination of education, and the increase in prohibited grazing and protected forest land led by the local government have caused the decrease in available feed resources, livestock numbers, milk production, and milk intake, it was suggested that Tigray farmers have possibly faced malnutrition and negative impacts on their health under the current political and social changes.

## 5. Conclusion

We have provided the preliminary results of a survey of the current dietary intake of Tigray farmers and an evaluation of how current local governmental policy and social changes have affected the farmers' dietary intake and nutritional status in southern Kilite Awlalelo district in the Eastern Zone of the Tigray Region. The characteristics of the dietary intake of the surveyed Tigray farmers were that they consumed a large amount of injera (*taita*) and bread (*gogo*), mainly with bean dishes (*shiro* or *shumshimo*) and chili pepper sauce (*silsi*), and seldom depended on meat, internal organs, and milk products in their daily meals. The main reason for the Tigray farmers' malnutrition was hypothesized to be a decrease in milk intake. The fact that milk products have also played an important role in the dietary intake of Tigray farmers is new evidence presented in this paper. Moreover, the suggestion that the nutrients of the Tigray farmers partially replenished certain nutrients via occasional special meals during festivals and religious events is a new aspect of the discussion on the nutritional intake of local Tigray farmers. These findings are based on detailed analysis of surveys conducted during extended stays in Tigray households. These surveys are, however, based on a small number of households. It is necessary to survey more households over a wider area to increase the reliability of the

results.

Population increases, the greater availability of education, and the increase in prohibited grazing and protected forest land led by the local government have resulted in the decreases in available feed resources, livestock numbers, milk production, and milk intake. It was suggested that Tigray farmers have possibly faced malnutrition and negative impacts on their health as a result of current political and social changes. The harvesting of haerbaceous plants is allowed only in prohibited grazing and protected forest land. Abundant feed resources, however, remain in these areas that cannot be utilized by local farmers. If the local farmers can utilize what resources are available to them efficiently, the local government will support the purchase of combines to harvest in prohibited grazing and protected forest land as well as the construction of paved roads that will provide access to motor vehicles to transport the harvest back to the village. The local government needs to implement a comprehensive policy that considers the subsistence and health of local peoples, rather than simply considering the conservation of the local natural environment.

## Notes

- A) In the Tigray Region, 'tmad' is used as the unit of agricultural land area. One tmad represents the area that can be plowed in one day by two bulls and is equivalent to approximately 0.25 ha. Household G owned 9 tmad farmland.
- B) These values are based on Japanese nutritional standards (Kagawa, 2006).

## Acknowledgements

This study was partly funded by a grant from Yotsuba Milk Products Co., Ltd., Japan in F. Y. 2015. It was the result of a research project entitled 'Forest and Farmland Conservation for Watershed Management in the Ethiopian Highlands (FFCW)' of the Japan International Research Center for Agricultural Sciences (JIRCAS) in F. Y. 2019. The authors owe a great deal of thanks to the local farmers in Tigray for offering their hospitality and kindness.

## References

- Bernus E. (1988): Seasonality, climatic fluctuations, and food supplies. In de Garine I., Harrison G. A. eds., *Coping with uncertainty in food supply*. Oxford University Press, Oxford, pp. 318-336.
- Coughenour M. B., Ellis J. E., Swift D. M., Coppock D. L., Galvin K., McCabe J. T., Hart T. C. (1985): Energy extraction and use in a nomadic pastoral ecosystem. *Science*, **230**: 619-625.
- Desalegn B. B., Lambert C., Didel S., Negese T., Biesalski H. K. (2018): Ethiopian Orthodox Fasting and Lactating Mothers: Longitudinal Study on Dietary Pattern and Nutritional Status in Rural

- Tigray, Ethiopia. *International Journal of Environmental Research and Public Health*, **15**: 1767.
- FAO (2004): *Human energy requirements. Scientific background papers from the joint FAO/WHO/UNU Expert Consultation*. FAO, Rome, 96p.
- Galvin K. A., Coppock D. L., Leslie P. W. (1994): Diet, nutrition, and the pastoral strategy. In Fratkin E., Galvin K. A., Roth E. A. eds., *African pastoralist systems: an integrated approach*. Lynne Rienner, Boulder, pp. 113-132.
- Hailelassie K., Mulugeta A., Girma M. (2013): Feeding practices, nutritional status and associated factors of lactating women in Samre Woreda, South Eastern Zone of Tigray, Ethiopia. *Nutritional Journal*, **12**: 28.
- Hirata M. (2010): Subsistence of agro-pastoralists in hilly high altitude of Ladakh, northern India: From point view of food intake in Domkhar villages. *Himalayan Study Monographs*, **11**: 61-77. In Japanese.
- Hirata M. (2012a): Mutually Complementary Relationship between Milk and Milk Products and Meat and Innards as Used by the Mongolian Nomad: Case Study of a Household in Dund-govi Province. *Japanese Journal of Cultural Anthropology*, **77**(1): 128-143. In Japanese.
- Hirata M. (2012b): Preliminary survey about the subsistence of a nomad in Chantang area, northern slope of west Himalayan mountain, northern India: From the case study of food intake in a D household of Karnak-pa nomad. *Himalayan Study Monographs*, **12**: 128-141. In Japanese.
- Hirata M., Oniki S., Kagatsume M., Uchida K., Katano N. (2013): Milk processing system and uses of milk products in the middle highland of Ethiopia. *Milk Science*, **62**(1): 1-10. In Japanese.
- Hirata M., Ogawa R., Gebremedhin B. G., Takenaka K. (2018): The recent decrease in the number of livestock and its cause for the agro-pastoralists in the Ethiopian highland- From the cases in southern Kilite Awlaelo district in eastern Tigray region. *Journal of Arid Land Studies*, **28**(1): 1-15.
- Hirata M., Ogawa R., Gebremedhin B.G., Sakai T., Koda K., Miyazaki N., Takenaka K. Forest conservation from the perspective of local fuel production and its consumption in the southern part of Kilite Awlaelo district in the Eastern zone of the Tigray Region, Ethiopia. *Journal of Arid Land Studies*, (Under printing).
- Jenness R., Sloan R. E. (1970): The composition of milks of various species, a review. *Dairy Science Abstract*, **32**: 599-612.
- Kagawa Y. (2006): *Standard Tables of Food Composition in Japan. Fifth Revised and Enlarged Edition*. Kagawa Nutrition University Publishing, Tokyo.
- Mulugeta A., Hagos F., Stoecker B., Kruseman G., Linderhof V., Abraha Z., Yohannes M., Samuel G. G. (2009): Nutritional Status of Adolescent Girls from Rural Communities of Tigray, Northern Ethiopia. *The Ethiopian Journal of Health Development*, **23**(1): 5-11.
- Mulugeta A., Hagos F., Kruseman G., Linderhof V., Stoecker B., Abraha Z., Yohannes M., Samuel G. G. (2010): Child malnutrition in Tigray, northern Ethiopia. *East African Medical Journal*, **87**(6): 248-254.
- National Meteorological Agency (2012): *Monthly air temperature and monthly precipitation in Mekele and Ab'ala*. National Meteorological Agency, Ethiopia.
- Nedessa, B., Nyborg I., Ali J. (2005): Exploring ecological and socio-economic issues for the improvement of area enclosure management: a case study from Ethiopia. *Drylands Coordination Group (DCG) Report*.
- Nestel P. (1986): A society in transition: developmental and seasonal influences on the nutrition of Maasai women and children. *Food and Nutrition Bulletin*, **8**: 2-18.
- Regional Land Use Planning Division (2000): *Report of environmental protection*. Land administration and use authority of Tigray, Mekelle.
- Tigray Forestry Action Plan (1996): *Tigray Bureau of Agriculture and Natural Resources Development*. Regional Government of Tigray, Mekelle, 122 p.
- Wagenaar-Brouwer M. (1985): Preliminary findings on the diet and nutritional status of some Tamasheq and Fulani groups in the Niger Delta of Central Mali. In Hill G. G. ed, *Population, health and nutrition in the Sahel: issues in the welfare of selected West African communities*. Kegan Paul International, London, pp. 226-2252.
- Woreda Kilteawlaelo Planning and Finance office (2019a): *Population and household of Kilte Awlaelo Woreda in 2017/2018*. Woreda Kilteawlaelo Planning and Finance office. Regional Government of Tigray, Mekelle.
- Woreda Kilteawlaelo Planning and Finance office (2019b): *Total livestock population of each Tabia of Kilte Awlaelo Woreda in 2017/2018*. Regional Government of Tigray, Mekelle.
- Yami M., Mekuria W., Hauser M. (2013): The effectiveness of village bylaws in sustainable management of community-managed enclosures in Northern Ethiopia. *Sustainability Science*, **8**(1): 73-86.
- Yoshida Y. (2000): *Story of Beans*. Heibonsha Publisher, Tokyo. In Japanese.

## エチオピア北部キリテ・アウラエロ郡南部のティ グライ牧畜民の食料摂取についての予備的調査

平田昌弘<sup>\*1)</sup>・盛 利隆<sup>1)</sup>・Birhane Gebreanenia GEBREMEDHIN<sup>2)</sup>・鬼木俊次<sup>3)</sup>・竹中浩一<sup>3)</sup>

**要旨：**エチオピア北部ティグライ州西部地区では、近年の地方自治体主導による森林保全・放牧禁止地域の拡大や社会変化により、家畜を放牧する場所が縮小し、現地農民が所有する家畜頭数は減少傾向にある。家畜飼養頭数の減少が、現地農民の食料摂取を低減させていることが懸念されている。そこで本研究の目的は、エチオピア北部ティグライ州西部地区キリテ・アウラエロ郡において、1) ティグライ農耕民の現在の食料摂取量とその特徴を把握し、2) 近年の地方自治体による政策や社会・経済状況の変化がティグライ農耕民の食料摂取や栄養状況にいかに関与しているかについて考察するための予備的調査を実施することにある。2015年2月・3月、2019年9月にTigray農耕民3世帯に滞在し、合計10人に対して食料摂取量を実測した。また、1970年頃の食料摂取、家畜頭数と乳量、乳製品の食料摂取に占める割合、放牧地の状況を把握するために、49歳～75歳の合計10人に対してインタビュー調査を実施した。調査をおこなったティグライ農耕民の食料摂取の特徴は、日常の食事においては大量のインジェラ (*taita*) とパン (*gogo*) を摂取し、マメ料理 (*shiro* と *shumshimo*) と赤トウガラシソース (*silsi*) を付け合わせて日常食とし、肉・内臓料理や乳・乳製品にはほとんど依存しておらず、エネルギー摂取量、タンパク質摂取量、脂質摂取量は不足傾向にあった。正月などの祭りや葬式などの法事の際に供される非日常の特別な食事で栄養分を補充していることが示唆された。人口増加、教育の普及、森林保全・禁止放牧地の増加の結果、家畜飼養頭数と乳・乳製品の生産量は減少し、乳・乳製品の摂取量が減少することとなり、ティグライ農耕民は栄養摂取不足に陥り、地域農民の健康に悪影響を及ぼしていることが示唆された。地方自治体は、単に地域の自然環境保全を考えた政策ではなく、そこに暮らす人々の生業や健康にも配慮した総合的な政策を講ずる必要がある。今後、結果の信頼性を増すために、より広域でより多数の事例を調査していくことが求められる。

キーワード：食料摂取、家畜頭数、乳・乳製品、栄養摂取不足、地方自治体政策

\*Corresponding Author: masa@obihiro.ac.jp

(2019年12月20日受付：2020年11月30日受理)

〒080-8555 北海道帯広市稲田町西2線-11 Tel: 0155-49-5485 Fax: 0155-49-5593

1) 帯広畜産大学

2) College of Dry Land Agriculture and Natural Resources, Mekelle University

3) 国際農林水産業研究センター