REVIEW ARTICLE Agricultural Reviews



Early Growth and Reproductive Performance of Crossbred Dairy Cattle in Ethiopia: A Review

Nibo Beneberu¹, Fikadu Wodajo¹

10.18805/ag.RF-278

ABSTRACT

The economy of livestock production largely depends upon the early growth and reproductive efficiency of the animals. This review was conducted to generate the database about the early growth and reproductive traits of crossbred cattle such as birth weight (BW), age at first service (AFS) and age at first calving (AFC) under Ethiopian conditions. The effort was made to collect and discuss all the published materials in the required areas in order to provide piece of information pertaining to early growth and reproductive traits of crossbred dairy cattle. In order to achieve the best early growth and reproductive performance in dairy animals, it is concluded that management system improvement, including effective heat detection and timely insemination, better health management, genetic improvement of crossbreeding and supplementation of good quality and quantity feed resources, is necessary.

Key words: Early, Growth traits, Reproductive trait.

Ethiopia is one of the developing countries in Africa known with a huge livestock population. The estimated total cattle population for the country is about 70 million constituting of 44% males and 56% females and the proportion of indigenous breed is 97.4% hybrid and exotic breeds are about 2.3% and 0.31%, respectively (CSA, 2020/2021). The dairy industry in Ethiopia is still not well developed compared to east African countries like Kenya, Tanzania and Uganda (Hunduma, 2013).

Cattle's total productivity and adaptation efficiency are heavily reliant on their reproductive success in a particular environment. Reproduction is an indication of reproductive efficiency and the pace of genetic advancement in both selection and crossbreeding programs, notably in dairy production systems.

Reproductive characteristics are critical variables in dairy production profitability (Fikre *et al.*, 2007). Female reproductive performance is one of the most significant factors in cattle production. AFS and AFC can be used to evaluate reproductive performance. According to Tadesse (2014), a cow's reproductive efficacy impacts its lifetime production. The first calving signifies the beginning of a cow's productive life and is directly tied to generation interval. Therefore, the objective of this review was focused on reviewing and generating compiled information on early growth and reproductive performance of crossbred dairy cattle in Ethiopia.

Growth performance of crossbred dairy cattle Birth weight

The birth weight performance of crossbred dairy cattle was evaluated by researchers under different agroclimatic conditions as well as managemental systems. The birth weight reported weights Jersey (J) × Horro (HO) at BARC

¹Ethiopian Institute of Agricultural Research, Holetta Agricultural Research Center. P.O.Box 2003 Addis Ababa or 31 Holetta, Ethiopia.

Corresponding Author: Fikadu Wodajo, Ethiopian Institute of Agricultural Research, Holetta Agricultural Research Center. P.O.Box 2003 Addis Ababa or 31 Holetta, Ethiopia.

Email: fikadu121084z@gmail.com

How to cite this article: Beneberu, N. and Wodajo, F. (2023). Early Growth and Reproductive Performance of Crossbred Dairy Cattle in Ethiopia: A Review. Agricultural Reviews. DOI: 10.18805/ag.RF-278.

(Bako Agricultural Research center) and Holstein Friesian (HF) × Fogera (FO) crossbred cattle at ALRC (Andassa Livestock Research Center), 19.1 kg and 23.5 kg (Habtamu Abera *et al.*, 2012; Addisu Bitew *et al.*, 2010), respectively. It is also assessed with different genotypes utilising data obtained from ranch and research centre since evaluating performance on farm data is challenging due to a lack of record keeping and unknown blood level/genotype of handled/reared animals.

The research conducted at Metekel Cattle Breeding Improvement Ranch for 50, 75 and 87.5% HF \times Fogera was 24.58±0.10, 26.56±0.26 and 26.45±0.73 kg, respectively (Belay Zeleke, 2014). Based on the reports on Aynalem Haile et al. (2011) the performance of birth weight for 50, 62.5, 75, 87.5% HF \times Boran crossbred were 26±0.15, 29.2±0.36, 31.1±0.28 and 31.4±0.27 kg, respectively. In both Boran and Fogera crosses, the performance of the herd increase as blood level increases. The birth weight performances of different crossbred dairy cattle are presented in Table 1.

Volume Issue

Table 1: Birth weight for crossbred dairy cattle with different genetic group in Ethiopia.

1 50% HF × BO	No	Breed genotype	BW (Kg)	Study sites	Source
3	1	50% HF × BO	24.36±0.14	Abernosa ranch	Ababu et al., 2006
4 50% HF × Ba (F1) 25.5±0.4 On-station Sendros et al., 2003 6 50% HF × Ba (F2) 28.2±0.6 On-station Sendros et al., 2003 6 50% HF × BO 28.2±0.65 On-station Sendros et al., 2003 7 50% HF × BO 26.0±15 On-station Aynalem et al., 2001 8 50% HF × BO(F1) 25.7±0.3 On-station Sendros et al., 2003 9 50% HF × BO(F1) 25.3±0.26 HARC/on-station Berhanu, 2008 10 50% HF × BO(F2) 27.9±0.4 On-station Berhanu, 2008 11 50% HF × BO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 12 50% HF × BO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 13 50% HF × HO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 14 50% HF × HO(F2) 26.1±0.6 On-station Sendros et al., 2003 15 50% HF × BO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 16 50% HF × BO(F2) 27.8±0.25 HARC/on-station Sendros et al., 2003 16 50% HF × BO F1 25.08±0.14 On-station Sendros et al., 2003 17 50% HF × BO F1 25.08±0.14 On-station Fikadu, 2020 18 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 19 50% J × Ba(F1) 21.6±0.5 ALF/on-station Abdinasir and Eskil, 200 20 50% J × Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 21 50% J × BA(F1) 21.6±0.5 On-station Sendros et al., 2003 22 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 22 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 23 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 25 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 26 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 27 50% J × BO(F1) 19.9±0.4 On-station Sendros et al., 2003 28 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 29 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 20 50% J × BO(F2) 22.8±0.6 On-station Sendros et al., 2003 20 50% J × BO(F2) 22.8±0.6 On-station Sendros et al., 2003 20 50% J × BO(F2) 22.8±0.0 On-station Sendros et al., 2003 20 50% J × BO(F2) 20.0 On-station Sendros et al., 2003 20 50% J × BO(F2) 20.0 On-station Sendros et al., 2003 20 50% J × BO(F2) 20.0 On-station Sendros et al	2	50% HF × FO	24.58±0.10	MCBIR /on-station	Belay, 2014
5 5 0% HF × Ba(F2) 28.2±0.6 On-station Sendros et al., 2003 5 50% HF × BO 26.2±0.65 HARC/on-station Gizachew et al., 2003 7 50% HF × BO 26.0±15 On-station Aynalem et al., 2013 8 50% HF × BO(F1) 25.7±0.3 On-station Sendros et al., 2003 9 50% HF × BO(F2) 27.9±0.4 On-station Sendros et al., 2003 10 50% HF × BO/F2 27.8±0.25 HARC/on-station Berhanu, 2008 11 50% HF × BO/F2 27.8±0.25 HARC/on-station Berhanu, 2008 12 50% HF × BO/F2 27.8±0.25 HARC/on-station Berhanu, 2008 13 50% HF × HO(F1) 22.9±0.4 On-station Sendros et al., 2003 14 50% HF × HO(F1) 22.9±0.4 On-station Sendros et al., 2003 15 50% HF × HO(F2) 26.1±0.6 On-station Sendros et al., 2003 16 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 17 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 18 50% HF × BO F2 24.6±0.5 ALF/on-station Fikadu, 2020 18 50% HF × BO F3 0.83±0.29 On-station Fikadu, 2020 18 50% HF × BO F3 0.83±0.29 On-station Sendros et al., 2003 18 50% HF × BO F3 0.83±0.29 On-station Sendros et al., 2003 18 50% HF × BO F3 0.83±0.29 On-station Fikadu, 2020 19 50% J × Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 20 50% J × Ba(F1) 21.5±0.3 On-station Sendros et al., 2003 20 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 20 50% J × BO(F1) 22.8±0.4 HARC/on-station Berhanu, 2008 20 50% J × BO(F1) 22.8±0.4 On-station Sendros et al., 2003 20 50% J × BO(F1) 20.91±0.44 HARC/on-station Berhanu, 2008 20 50% J × BO(F1) 0.91±0.44 HARC/on-station Sendros et al., 2003 20 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 20 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 20 50% HF × BO 0 48.3±2.33 HARC/on-station Sendros et al., 2003 20 50% HF × BO 0 48.3±2.33 HARC/on-station Sendros et al., 2003 20 50% HF × BO 0 40.5±0.4 HARC/on-station Sendros et al., 2003 20 50% HF × BO 0 50.5±0.5 On-station Sendros et al., 2003 20 50% HF × BO 0 50.5±0.5 On-station Sendros et al., 2003 20 50% HF × BO 0 50.5±0.5 On-station Sendros et al., 2003 20 50% HF × BO 0 50.5±0.5 On-station Sendros e	3	50% HF × A	21.5±0.5	ALF/on-station	Abdinasir and Eskil, 2001
6 50% HF × BO 26±0.15 On-station Gizachew et al., 2003 8 50% HF × BO(F1) 25.7±0.3 On-station Aynalem et al., 2011 8 50% HF × BO(F2) 27.9±0.4 On-station Sendros et al., 2003 9 50% HF × BO(F2) 27.9±0.4 On-station Sendros et al., 2003 11 50% HF × BO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 12 50% HF × BO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 13 50% HF × BO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 14 50% HF × BO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 15 50% HF × HO(F1) 22.9±0.4 On-station Sendros et al., 2003 16 50% HF × BO(F2) 28.5±0.4 On-station Sendros et al., 2003 16 50% HF × BO F1 25.08±0.14 On-station Fikadu, 2020 17 50% HF × BO F1 25.08±0.14 On-station Fikadu, 2020 18 50% HF × BO F2 28.5±0.2 On-station Fikadu, 2020 18 50% HF × BO F3 26.8±0.29 On-station Fikadu, 2020 19 50% J × Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 20 50% J × Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 20 50% J × Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 20 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 22 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 23 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 25 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 26 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 27 50% J × BO(F1) 20.91±0.44 HARC/on-station Sendros et al., 2003 28 50% J × BO(F1) 21.9±0.4 On-station Sendros et al., 2003 28 50% J × BO(F1) 20.91±0.4 HARC/on-station Sendros et al., 2003 29 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 29.9±0.7 On-station Sendros et al., 2003 31 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 32 50% J × BO(F1) 29.9±0.4 On-station Sendros et al., 2003 33 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 34 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 36 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 37 75% HF × BO 12.9±0.4 On-station Sendros et al., 2003	4	50% HF × Ba (F1)	25.5±0.4	On-station	Sendros et al., 2003
7 50% HF × BO 26±0.15 On-station Aynalem et al., 2011 8 50% HF × BO(F1) 25.7±0.3 On-station Sendros et al., 2003 9 50% HF × BO(F2) 27.9±0.4 On-station Sendros et al., 2003 10 50% HF × BO(F2) 27.9±0.4 On-station Berhanu, 2008 11 50% HF × BO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 12 50% HF × BO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 12 50% HF × BO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 14 50% HF × HO(F1) 22.9±0.4 On-station Sendros et al., 2003 14 50% HF × HO(F2) 26 1±0.6 On-station Sendros et al., 2003 15 50% HF × BO F1 25.0±0.14 On-station Sendros et al., 2003 15 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 16 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 17 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 18 50% J× Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 250% J× Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 250% J× Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 250% J× Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 250% J× BO(F1) 21.5±0.3 On-station Sendros et al., 2003 250% J× BO(F1) 21.5±0.3 On-station Sendros et al., 2003 250% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 250% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 250% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 250% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 250% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 250% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 250% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 250% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 250% J× BO(F2) 22.8±0.6 On-station Sendros et al., 2003 250% J× BO(F2) 22.8±0.6 On-station Sendros et al., 2003 250% J× BO(F2) 22.2±0.6 On-station Sendros et al., 2003 250% HF × BO 28.5±0.94 HARC/on-station Sendros et al., 2003 250% HF × BO 28.5±0.94 HARC/on-station Sendros et al., 2003 250% HF × BO 28.5±0.94 HARC/on-station Sendros et al., 2003 250% HF × BO 28.5±0.94 HARC/on-station Sendros et al., 2003 250% HF × BO 29.5±0.06 On-station Sendros et al., 2003 250% HF × BO 20.5±0.06 On-station Sendros et al., 2003	5	50% HF × Ba(F2)	28.2±0.6	On-station	Sendros et al., 2003
8	6	50% HF × BO	28.2±0.65	HARC/on-station	Gizachew et al., 2003
9 50% HF × BO(F2) 27.9±0.4 On-station Sendros et al., 2003 10 50% HF × BO(F1 25.3±0.26 HARC/on-station Berhanu, 2008 Berhanu, 2008 115 50% HF × BO/F2 27.8±0.25 HARC/on-station Berhanu, 2008 12 50% HF × BO(F2) 27.8±0.25 HARC/on-station Berhanu, 2008 13 50% HF × BO(F2) 27.8±0.25 HARC/on-station Sendros et al., 2003 14 50% HF × BO(F2) 26.1±0.6 On-station Sendros et al., 2003 15 50% HF × BO F1 25.0±0.14 On-station Fikadu, 2020 Fikadu, 2020 16 50% HF × BO F2 28.5±0.21 On-station Fikadu, 2020 17 50% HF × BO F3 26.8±0.21 On-station Fikadu, 2020 18 50% HF × Z 24.6±0.5 ALF/on-station Abdinasir and Eskil, 2003 50% J × Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 20 50% J × Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 21 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 22 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 22 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 25.5 J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 25.5 J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 25.5 J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 25.5 J × BO(F1) 20.9±0.44 HARC/on-station Berhanu, 2008 25.5 SO% J × BO(F1) 20.9±0.44 HARC/on-station Sendros et al., 2003 25.5 J × BO(F1) 20.9±0.44 HARC/on-station Sendros et al., 2003 25.5 SO% J × BO(F1) 20.9±0.44 HARC/on-station Sendros et al., 2003 25.5 SO% J × BO(F1) 20.9±0.44 HARC/on-station Sendros et al., 2003 25.5 SO% J × BO(F1) 20.9±0.44 HARC/on-station Sendros et al., 2003 25.5 SO% J × BO(F1) 20.9±0.44 HARC/on-station Sendros et al., 2003 25.5 SO% HF × BO 26.5 SO% J × BO(F1) 20.9±0.0 Sendros et al., 2003 25.5 SO% J × BO(F1) 20.9±0.0 Sendros et al., 2003 25.5 SO% J × BO(F1) 20.9±0.0 Sendros et al., 2003 25.5 SO% HF × BO 26.5 SOM J × BO(F1) 20.9±0.0 Sendros et al., 2003 25.5 SOM HF × BO 26.5 SOM J × BO(F1) 20.9±0.0 Sendros et al., 2003 25.5 SOM J × BO(F1) 20.9±0.0 Sendros et al., 2003 25.5 SOM J × BO(F1) 20.9±0.0 Sendros et al., 2003 25.5 SOM J × BO(F1) 20.9±0.0 Sendros et al., 2003 25.5 SOM J × BO(F1) 20.9±0.0 Sendros et al., 2003 25.5 SOM J × BO(F1)	7	50% HF × BO	26±0.15	On-station	Aynalem et al., 2011
10 50% HF × BO/F1 25.38±0.26 HARC/on-station Berhanu, 2008 11 50% HF × BO/F2 27.84±0.25 HARC/on-station Berhanu, 2008 12 50% HF × BO/F2 27.84±0.25 HARC/on-station Berhanu, 2008 13 50% HF × HO(F1) 22.9±0.4 On-station Sendros et al., 2003 14 50% HF × HO(F2) 26.1±0.6 On-station Sendros et al., 2003 Fix 50% HF × HO(F2) 26.1±0.6 On-station Fixedu, 2020 Fix 50% HF × BO F1 25.08±0.14 On-station Fixedu, 2020 Fix 50% HF × BO F2 28.53±0.21 On-station Fixedu, 2020 Fix 50% HF × BO F2 28.53±0.21 On-station Fixedu, 2020 Fix 50% HF × BO F2 28.53±0.29 On-station Fixedu, 2020 Fix 50% HF × BO F3 26.83±0.29 On-station Fixedu, 2020 Fix 50% HF × BO F3 26.83±0.29 On-station Abdinasir and Eskil, 2003 50% J× Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 50% J× Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 50% J× Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 22 50% J× BO(F1) 21.5±0.3 On-station Sendros et al., 2003 50% J× BO(F1) 21.5±0.3 On-station Sendros et al., 2003 50% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 50% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 50% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 50% J× BO(F2) 22.00.6 On-station Sendros et al., 2003 50% J× HO(F1) 19.9±0.4 On-station Sendros et al., 2003 50% J× HO(F2) 22.00.6 On-station Sendros et al., 2003 50% J× HO(F2) 22.00.6 On-station Sendros et al., 2003 50% J× HO(F2) 22.00.6 On-station Sendros et al., 2003 60.5 HF × BO 28.9±0.7 On-station Sendros et al., 2003 60.5 HF × BO 28.9±0.7 On-station Sendros et al., 2003 60.5 HF × BO 28.9±0.7 On-station Sendros et al., 2003 60.5 HF × BO 60.0 11.9±0.9 On-station Sendros et al., 2003 60.5 HF × BO 60.0 11.9±0.9 On-station Sendros et al., 2003 60.5 HF × BO 60.0 11.9±0.9 On-station Sendros et al., 2003 60.5 HF × BO 60.0 11.9±0.9 On-station Sendros et al., 2003 60.0 11.9±0.9 O	8	50% HF × BO(F1)	25.7±0.3	On-station	Sendros et al., 2003
11 50% HF × BO/F2 27.84±0.25 HARC/on-station Berhanu, 2008 12 50% HF × BO/F2 27.84±0.25 HARC/on-station Berhanu, 2008 13 50% HF × BO/F1 27.84±0.25 HARC/on-station Berhanu, 2008 14 50% HF × HO(F1) 22.9±0.4 On-station Sendros et al., 2003 15 50% HF × BO F1 25.08±0.14 On-station Fikadu, 2020 16 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 17 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 18 50% HF × BO F3 26.83±0.29 On-station Abdinasir and Eskil, 200 18 50% HF × Z 24.6±0.5 ALF/on-station Abdinasir and Eskil, 200 19 50% J × Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 20 50% J × Ba(F1) 21.5±0.3 On-station Gizachew et al., 2003 21 50% J × BO 23±0.74 HARC/on-station Gizachew et al., 2003 22 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 23 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J × BO/F2 22.8±0.4 On-station Sendros et al., 2003 25 50% J × BO/F2 22.07±0.33 HARC/on-station Berhanu, 2008 26 50% J × BO/F2 22.07±0.33 HARC/on-station Berhanu, 2008 26 50% J × BO/F2 22.07±0.33 HARC/on-station Sendros et al., 2003 27 50% J × BO/F2 22.07±0.33 HARC/on-station Sendros et al., 2003 28 50% HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 30 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 31 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 32 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 33 62.5% J × BO 21.9±0.9 On-station Sendros et al., 2003 34 75% HF × BO 29.2±0.36 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 36 75% HF × BO 12.9±0.9 On-station Sendros et al., 2003 37 75% HF × BO 20.5±1.13 HARC/on-station Sendros et al., 2003 38 75% HF × BO 12.9±0.9 On-station Sendros et al., 2003 39 75% HF × BO 12.9±0.9 On-station Sendros et al., 2003 30 62.5% JF × BO 31.1±0.28 On-station Sendros et al., 2003 37 75% HF × BO 12.1±0.5 On-station Sendros et al., 2003 38 75% HF × BO 12.1±0.5 On-station Sendros et al., 2003 39 75% HF × BO 20.2±1.3±0.5 On-station Sendros et al	9	50% HF × BO(F2)	27.9±0.4	On-station	Sendros et al., 2003
12 50% HF × BO/F2 27.84±0.25 HARC/on-station Berhanu, 2008 13 50% HF × HO(F1) 22.9±0.4 On-station Sendros et al., 2003 14 50% HF × BO F1 25.08±0.14 On-station Fikadu, 2020 15 50% HF × BO F1 25.08±0.14 On-station Fikadu, 2020 16 50% HF × BO F2 28.5±0.21 On-station Fikadu, 2020 17 50% HF × BO F3 26.83±0.29 On-station Fikadu, 2020 18 50% HF × Z 24.6±0.5 ALF/on-station Abdinasir and Eskil, 2003 18 50% J × Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 20 50% J × Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 21 50% J × Bo(F1) 21.5±0.3 On-station Sendros et al., 2003 22 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 23 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 25 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 26 50% J × BO(F1) 20.91±0.44 HARC/on-station Berhanu, 2008 25 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 26 50% J × BO(F1) 0.91±0.4 On-station Sendros et al., 2003 27 50% J × BO(F2) 22.2±0.6 On-station Sendros et al., 2003 28 50% HF × BO 24.83±2.33 HARC/on-station Berhanu, 2008 28 50% HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 30 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 32 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 33 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 34 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 36 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 39 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 30 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 31 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 39 75% HF × BO 0 0.2.1±0.5 On-station Sendros et al., 2003 40 7	10	50% HF × BO/F1	25.38±0.26	HARC/on-station	Berhanu, 2008
133 50% HF × HO(F1) 22.9±0.4 On-station Sendros et al., 2003 144 50% HF × HO(F2) 26.1±0.6 On-station Sendros et al., 2003 155 50% HF × BO F1 25.08±0.14 On-station Fikadu, 2020 166 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 177 50% HF × BO F3 26.83±0.29 On-station Fikadu, 2020 178 50% HF × BO F3 26.83±0.29 On-station Fikadu, 2020 189 50% HF × Z 24.6±0.5 ALF/on-station Abdinasir and Eskil, 2003 199 50% J × Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 200 50% J × Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 21 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 22 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 23 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J × BO(F2) 22.07±0.33 HARC/on-station Berhanu, 2008 25 50% J × BO(F2) 22.07±0.33 HARC/on-station Berhanu, 2008 26 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 28 50% HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 29 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 33 62.5% J × BO(F1) 29.3±0.6 On-station Sendros et al., 2003 34 75% HF × BO 29.9±0.36 On-station Sendros et al., 2003 35 75% HF × BO 0 0.7±1.13 HARC/on-station Sendros et al., 2003 36 75% HF × BO 0 0.7±1.13 HARC/on-station Sendros et al., 2003 37 75% HF × BO 0 0.7±1.13 HARC/on-station Sendros et al., 2003 38 75% HF × BO 0 1.1±0.28 On-station Sendros et al., 2003 39 75% HF × BO 0 1.1±0.28 On-station Sendros et al., 2003 30 75% HF × BO 0 1.1±0.28 On-station Sendros et al., 2003 31 75% HF × BO 0 1.1±0.28 On-station Sendros et al., 2003 32 75% HF × BO 0 1.1±0.28 On-station Sendros et al., 2003 33 75% HF × BO 0 1.1±0.5 On-station Sendros et al., 2003 34 75% HF × BO 0 1.1±0.5 On-station Sendros et al., 2003 35 75% HF × BO 0 1.1±0.5 On-station Sendros et al., 2003 36 75% HF × BO 0 1.1±0.5 On-station Sendros et al., 2003 37 75% HF × BO 0 1.1±0.5 On-station Sendros et	11	50% HF × BO/F2	27.84±0.25	HARC/on-station	Berhanu, 2008
144 50% HF × HO(F2) 26.1±0.6 On-station Sendros <i>et al.</i> , 2003 15 50% HF × BO F1 25.08±0.14 On-station Fikadu, 2020 Fikadu, 2020 177 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 18 50% HF × BO F3 26.83±0.29 On-station Fikadu, 2020 18 50% HF × Z 24.6±0.5 ALF/on-station Abdinasir and Eskil, 2015 50% J× Ba(F1) 21.6±0.5 On-station Sendros <i>et al.</i> , 2003 20 50% J× Ba(F2) 23.3±0.5 On-station Sendros <i>et al.</i> , 2003 21 50% J× BO(F1) 21.5±0.3 On-station Sendros <i>et al.</i> , 2003 22 50% J× BO(F1) 21.5±0.3 On-station Sendros <i>et al.</i> , 2003 23 50% J× BO(F2) 22.8±0.4 On-station Sendros <i>et al.</i> , 2003 24 50% J× BO(F2) 22.8±0.4 On-station Sendros <i>et al.</i> , 2003 25 50% J× BO(F2) 22.07±0.33 HARC/on-station Berhanu, 2008 26 50% J× HO(F1) 19.9±0.4 On-station Berhanu, 2008 26 50% J× HO(F1) 19.9±0.4 On-station Sendros <i>et al.</i> , 2003 28 50% J× HO(F2) 22±0.6 On-station Sendros <i>et al.</i> , 2003 28 50% HF × BO 28.9±0.7 On-station Sendros <i>et al.</i> , 2003 31 62.5% HF × BO 28.9±0.7 On-station Sendros <i>et al.</i> , 2003 31 62.5% HF × BO 28.9±0.7 On-station Sendros <i>et al.</i> , 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros <i>et al.</i> , 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros <i>et al.</i> , 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros <i>et al.</i> , 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros <i>et al.</i> , 2003 31 62.5% HF × BO 31.1±0.28 On-station Sendros <i>et al.</i> , 2003 31 62.5% HF × BO 31.1±0.28 On-station Sendros <i>et al.</i> , 2003 31 62.5% HF × BO 31.1±0.28 On-station Sendros <i>et al.</i> , 2003 31 75% HF × BO(F2) 28.6±1.2 On-station Sendros <i>et al.</i> , 2003 31 75% HF × BO(F1) 29.7±0.4 On-station Sendros <i>et al.</i> , 2003 31 75% HF × BO 26.5±0.26 MCBIR /on-station Sendros <i>et al.</i> , 2003 31 75% HF × BO 31.1±0.28 On-station Sendros <i>et al.</i> , 2003 31 75% HF × BO 26.5±0.26 MCBIR /on-station Sendros <i>et al.</i> , 2003 31 75% HF × BO 26.5±0.26 MCBIR /on-station Sendros <i>et al.</i> , 2003 31 75% HF × BO 26.5±0.26 MCBIR /on-station Sendros <i>et al.</i> , 2003 31 75% HF × BO 27.1±0.5 On-station Sendros <i>et al.</i> , 2003 31 75% HF × BO 31.1±0.5 On-station Sendros <i>et al.</i>	12	50% HF × BO/F2	27.84±0.25	HARC/on-station	Berhanu, 2008
14 50% HF × HO(F2) 26.1±0.6 On-station Sendros et al., 2003 15 50% HF × BO F1 25.08±0.14 On-station Fikadu, 2020 Fikadu, 2020 17 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 18 50% HF × BO F3 26.83±0.29 On-station Fikadu, 2020 18 50% HF × Z 24.6±0.5 ALF/on-station Abdinasir and Eskil, 200 50% HF × BO J× Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 20 50% J× Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 21 50% J× BO(F1) 21.5±0.3 On-station Sendros et al., 2003 22 50% J× BO(F1) 21.5±0.3 On-station Sendros et al., 2003 23 50% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J× BO(F2) 22.091±0.44 HARC/on-station Berhanu, 2008 25 50% J× BO(F2) 22.07±0.33 HARC/on-station Berhanu, 2008 26 50% J× HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J× HO(F2) 22±0.6 On-station Sendros et al., 2003 28 50% HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 31 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 31 62.5% HF × BO 31.1±0.28 On-station Sendros et al., 2003 31 62.5% HF × BO 31.1±0.28 On-station Sendros et al., 2003 31 75% HF × BO(F2) 28.6±0.2 On-station Sendros et al., 2003 31 75% HF × BO(F2) 28.6±0.2 On-station Sendros et al., 2003 31 75% HF × BO(F2) 28.6±0.2 On-station Sendros et al., 2003 31 75% HF × BO 26.6±0.26 MCBIR /on-station Sendros et al., 2003 31 75% HF × BO(F2) 28.6±0.2 On-station Sendros et al., 2003 31 75% HF × BO(F2) 28.6±0.2 On-station Sendros et al., 2003 31 75% HF × BO 26.6±0.26 MCBIR /on-station Sendros et al., 2003 31 75% HF × BO 26.6±0.26 MCBIR /on-station Sendros et al., 2003 31 75% HF × BO 26.6±0.26 MCBIR /on-station Sendros et al., 2003 31 75% HF × BO 27.1±0.5 On-station Sendros et al., 2003 31 75% HF × BO 31.1	13	50% HF × HO(F1)	22.9±0.4	On-station	Sendros et al., 2003
166 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 177 50% HF × BO F3 26.83±0.29 On-station Fikadu, 2020 188 50% HF × Z 24.6±0.5 ALF/on-station Abdinasir and Eskil, 2001 189 50% J × Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 200 50% J × Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 211 50% J × BO 23±0.74 HARC/on-station Sendros et al., 2003 221 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 232 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 240 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 250 J × BO(F2) 22.07±0.33 HARC/on-station Berhanu, 2008 261 50% J × BO/F2 22.07±0.33 HARC/on-station Berhanu, 2008 262 50% J × BO/F2 22.07±0.33 HARC/on-station Sendros et al., 2003 270 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 280 50% HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 281 50% HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 282 50% HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 300 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 310 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 311 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 312 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 313 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 314 75% HF × BO 29.2±0.36 On-station Sendros et al., 2003 315 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 316 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 317 75% HF × BO(F1) 29.3±0.4 On-station Sendros et al., 2003 319 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 320 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 331 75% HF × BO 31.1±0.33 On-station Sendros et al., 2003 342 75% HF × BO 31.1±0.35 On-station Sendros et al., 2003 343 75% HF × BO 610 29.3±0.6 On-station Sendros et al., 2003 344 75% HF × BO 75%	14	50% HF × HO(F2)	26.1±0.6	On-station	
16 50% HF × BO F2 28.53±0.21 On-station Fikadu, 2020 17 50% HF × BO F3 26.83±0.29 On-station Fikadu, 2020 18 50% HF × Z 24.6±0.5 ALF/on-station Abdinasir and Eskil, 200 19 50% J × Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 20 50% J × Ba(F2) 23.3±0.74 HARC/on-station Sendros et al., 2003 21 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 22 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 23 50% J × BO/F2 22.07±0.33 HARC/on-station Berhanu, 2008 25 50% J × BO/F2 22.07±0.33 HARC/on-station Sendros et al., 2003 26 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J × HO(F2) 22±0.6 On-station Sendros et al., 2003 28 50%HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 29.2±0.36	15	50% HF × BO F1	25.08±0.14	On-station	Fikadu, 2020
177 50% HF × BO F3 26.83±0.29 On-station Fikadu, 2020 188 50% HF × Z 24.6±0.5 ALF/on-station Abdinasir and Eskil, 200 199 50% J × Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 201 50% J × Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 21 50% J × BO 23±0.74 HARC/on-station Gizachew et al., 2003 22 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 23 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J × BO(F1 20.91±0.44 HARC/on-station Berhanu, 2008 25 50% J × BO/F1 20.91±0.44 HARC/on-station Berhanu, 2008 26 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 28 50% HF × BO 22.6±0.6 On-station Sendros et al., 2003 29 62.5% HF × BO 24.83±2.33 HARC/on-station Yohannes, 2017 29 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 28.6±0.94 HARC/on-station Gizachew al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 33 62.5% J × BO 21.9±0.9 On-station Sendros et al., 2003 34 75% HF × BO 20.7±1.13 HARC/on-station Gizachew al., 2003 35 75% HF × BO 01.1±0.28 On-station Sendros et al., 2003 36 75% HF × BO 01.1±0.28 On-station Sendros et al., 2003 37 75% HF × BO 01.1±0.28 On-station Sendros et al., 2003 38 75% HF × BO 01.1±0.28 On-station Sendros et al., 2003 39 75% HF × BO 01.1±0.28 On-station Sendros et al., 2003 30 75% HF × BO 01.1±0.28 On-station Sendros et al., 2003 31 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 38 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 39 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 30 75% HF × BO 01.1±0.28 On-station Sendros et al., 2003 31 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 32 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 38 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 39 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 30 75% HF × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 31 75% HF × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 32 75% J × BO(F1) 21.1±0.5 On-station Sendros			28.53±0.21		
18 50% H× Z 24.6±0.5 ALF/on-station Abdinasir and Eskil, 200 19 50% J× Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 20 50% J× Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 21 50% J× BO(F1) 21.5±0.3 On-station Sendros et al., 2003 22 50% J× BO(F1) 21.5±0.3 On-station Sendros et al., 2003 23 50% J× BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J× BO(F1) 20.91±0.44 HARC/on-station Berhanu, 2008 25 50% J× BO(F1) 19.9±0.4 On-station Sendros et al., 2003 26 50% J× BO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J× HO(F1) 19.9±0.4 On-station Sendros et al., 2003 28 50% HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 30 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 32 62.5% J× B			26.83±0.29	On-station	
19 50% J × Ba(F1) 21.6±0.5 On-station Sendros et al., 2003 20 50% J × Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 21 50% J × BO 23±0.74 HARC/on-station Sendros et al., 2003 22 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 23 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J × BO/F2 22.07±0.33 HARC/on-station Berhanu, 2008 25 50% J × BO/F2 22.07±0.33 HARC/on-station Sendros et al., 2003 26 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J × HO(F2) 22±0.6 On-station Sendros et al., 2003 28 50%HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 30 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 31 62.5% HF × BO 28.6±0.94 HARC/on-station Gizachew al., 2003 31 62.5% J × BO 29.2±0.36 On-station Aynalem et al., 2011 32 62.5% J × BO 21.9±0.9 On-station Sendros et al., 2003 33 62.5% J × BO 20.7±1.13 HARC/on-station Sendros et al., 2003 34 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 36 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 37 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 39 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 30 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 30 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 31 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 39 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 30 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 30 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 31 75% HF × BO(F2) 27.0±0.8 ALF/on-station Sendros et al., 2003 32 75% HF × BO(F2) 27.0±0.8 ALF/on-station Sendros et al., 2003 34 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.5 On-station Sendros et al., 2003 36 75% HF × BO 31.0±0.5 On-station Sendros et al., 2003 37 75% HF × BO 31.0±0.5 On-station Sendros et al., 2003 38 75% HF × BO 31.74±0.29 HARC/on-station Sendros et al., 2003	18			ALF/on-station	·
20 50% J × Ba(F2) 23.3±0.5 On-station Sendros et al., 2003 21 50% J × BO 22±0.74 HARC/on-station Gizachew et al., 2003 22 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 23 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J × BO(F1) 20.91±0.44 HARC/on-station Berhanu, 2008 25 50% J × BO/F2 22.07±0.33 HARC/on-station Berhanu, 2008 26 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J × HO(F2) 22±0.6 On-station Sendros et al., 2003 28 50% HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 29 62.5% HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 30 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Gizachew al., 2003 31 62.5% J × BO 21.9±0.9 On-station Aynalem et al., 2011 32 62.5% J × BO 20.7±1.13 HARC/on-station Gizachew et al., 2003 33 62.5% J × BO 20.7±1.13 HARC/on-station Gizachew et al., 2003 34 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 36 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 37 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 38 75% HF × BO 13.1±0.28 On-station Sendros et al., 2003 39 75% HF × BO 72 31.3±0.33 On-station Sendros et al., 2003 30 75% HF × BO 12.5±0.5 On-station Sendros et al., 2003 31 75% HF × BO 12.5±0.5 On-station Sendros et al., 2003 32 75% HF × BO 12.1±0.5 On-station Sendros et al., 2003 33 75% HF × BO 12.1±0.5 On-station Sendros et al., 2003 34 75% J × BO 12.1±0.5 On-station Sendros et al., 2003 35 75% J × BO 12.1±0.5 On-station Sendros et al., 2003 36 75% HF × BO 12.1±0.5 On-station Sendros et al., 2003 37 75% HF × BO 12.1±0.5 On-station Sendros et al., 2003 38 75% J × BO 12.1±0.5 On-station Sendros et al., 2003 39 75% J × BO 12.1±0.5 On-station Sendros et al., 2003 40 75% J × BO 12.1±0.5 On-station Sendros et al., 2003 41 75% J × BO 12.1±0.5 On-station Sendros et al., 2003 42 75% J × BO 12.1±0.5 On-station Sendros et al., 2003 43 75% J × BO 12.1±0.5 On-station Sendros et al., 2003					
21 50% J × BO 23±0.74 HARC/on-station Gizachew et al., 2003 22 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 23 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J × BO/F1 20.91±0.44 HARC/on-station Berhanu, 2008 25 50% J × BO/F2 22.07±0.33 HARC/on-station Berhanu, 2008 26 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J × HO(F2) 22±0.6 On-station Sendros et al., 2003 28 50% HF × BO 24.83±2.33 HARC/on-station Sendros et al., 2003 30 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Gizachew al., 2003 31 62.5% J × BO 29.2±0.36 On-station Aynalem et al., 2011 32 62.5% J × BO 29.2±0.36 On-station Sendros et al., 2003 33 62.5% J × BO 20.7±1.13 HARC/on-station Gizachew et al., 2003 34 75% HF × BG(F1) 29.3±0.6 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 36 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 37 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 38 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 39 75% HF × BO 62 31.31±0.33 On-station Sendros et al., 2003 40 75% HF × BO 72 31.31±0.33 On-station Sendros et al., 2003 41 75% HF × BO P2 31.31±0.33 On-station Sendros et al., 2003 42 75% HF × BO P2 31.31±0.33 On-station Sendros et al., 2003 43 75% HF × BO P2 31.31±0.33 On-station Sendros et al., 2003 44 75% HF × BO P2 31.31±0.33 On-station Sendros et al., 2003 45 75% HF × BO O1.21.3±0.6 On-station Sendros et al., 2003 46 75% HF × BO O1.21.3±0.6 On-station Sendros et al., 2003 47 75% HF × BO O1.3±0.5 On-station Sendros et al., 2003 48 75% HF × BO O1.21.3±0.6 On-station Sendros et al., 2003 49 75% HF × BO O1.21.3±0.6 On-station Sendros et al., 2003 40 75% HF × BO O1.21.3±0.6 On-station Sendros et al., 2003 41 75% HF × BO O1.21.3±0.6 On-station Sendros et al., 2003 42 75% HF × BO O1.21.3±0.5 On-station Sendros et al., 2003 43 75% HF × BO O1.21.3±0.5 On-station Sendros et al., 2003 44 75% HF × BO O1.21.3±0.5 On-station Sendros et al., 2003 45 75% HF × BO O1.21.3±0.5 On-		` '			,
22 50% J × BO(F1) 21.5±0.3 On-station Sendros et al., 2003 3 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J × BO/F1 20.91±0.44 HARC/on-station Berhanu, 2008 25 50% J × BO/F2 22.07±0.33 HARC/on-station Sendros et al., 2003 26 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J × HO(F2) 2±0.6 On-station Sendros et al., 2003 28 50%HF × BO 24.83±2.33 HARC/on-station Yohannes, 2017 29 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 28.0±0.94 HARC/on-station Gizachew al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Aynalem et al., 2011 32 62.5% J × BO 21.9±0.9 On-station Sendros et al., 2003 33 62.5% J × BO 21.9±0.9 On-station Sendros et al., 2003 34 75% HF × BG(F1) 29.3±0.6 On-station Gizachew et al., 2003 35 75% HF × BO(1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 38 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 39 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 30 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 31 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 39 75% HF × BO 26.55±0.26 MCBIR /on-station Belay, 2014 40 75% HF × TO 26.55±0.26 MCBIR /on-station Sendros et al., 2003 41 75% HF × BO 22.13±0.37 HARC/on-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Sendros et al., 2003 44 75% J × BO(F1) 21.3±0.6 On-station Sendros et al., 2003 45 75% J × BO 31.74±0.29 HARC/on-station Sendros et al., 2003 46 75% HF × A 24.6±0.6 ALF/on-station Sendros et al., 2003		, ,			•
23 50% J × BO(F2) 22.8±0.4 On-station Sendros et al., 2003 24 50% J × BO/F1 20.91±0.44 HARC/on-station Berhanu, 2008 25 50% J × BO/F2 22.07±0.33 HARC/on-station Berhanu, 2008 26 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J × HO(F2) 22±0.6 On-station Sendros et al., 2003 28 50%HF × BO 24.83±2.33 HARC/on-station Yohannes, 2017 29 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 28.6±0.94 HARC/on-station Gizachew al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Sendros et al., 2003 32 62.5% J × BO 21.9±0.9 On-station Sendros et al., 2003 34 75% HF × Ba(F1) 29.3±0.6 On-station Sendros et al., 2003 35 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 36 75% HF × BO(F2) 28.6±1.2					
24 50% J × BO/F1 20.91±0.44 HARC/on-station Berhanu, 2008 25 50% J × BO/F2 22.07±0.33 HARC/on-station Berhanu, 2008 26 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J × HO(F2) 22±0.6 On-station Sendros et al., 2003 28 50%HF × BO 24.83±2.33 HARC/on-station Yohannes, 2017 29 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 28.6±0.94 HARC/on-station Gizachew al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Aynalem et al., 2011 32 62.5% J × BO 21.9±0.9 On-station Sendros et al., 2003 33 62.5% J × BO 20.7±1.13 HARC/on-station Sendros et al., 2003 34 75% HF × Ba(F1) 29.3±0.6 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Sendros et al., 2003 37 75% HF × BO(F1) 29.7±0.4		` '			
25 50% J × BO/F2 22.07±0.33 HARC/on-station Berhanu, 2008 26 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J × HO(F2) 22±0.6 On-station Sendros et al., 2003 28 50%HF × BO 24.83±2.33 HARC/on-station Yohannes, 2017 29 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 28.6±0.94 HARC/on-station Gizachew al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Aynalem et al., 2011 32 62.5% J × BO 21.9±0.9 On-station Gizachew et al., 2003 33 62.5% J × BO 20.7±1.13 HARC/on-station Gizachew et al., 2003 34 75% HF × Ba(F1) 29.3±0.6 On-station Aynalem et al., 2011 35 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 36 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO F2 31.3±0.33 <td></td> <td>` '</td> <td></td> <td></td> <td>·</td>		` '			·
26 50% J × HO(F1) 19.9±0.4 On-station Sendros et al., 2003 27 50% J × HO(F2) 22±0.6 On-station Sendros et al., 2003 28 50% HF × BO 24.83±2.33 HARC/on-station Yohannes, 2017 29 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 28.6±0.94 HARC/on-station Gizachew al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Aynalem et al., 2011 32 62.5% J × BO 21.9±0.9 On-station Gizachew et al., 2003 33 62.5% J × BO 20.7±1.13 HARC/on-station Gizachew et al., 2003 34 75% HF × Ba(F1) 29.3±0.6 On-station Aynalem et al., 2003 35 75% HF × BO 31.1±0.28 On-station Aynalem et al., 2011 36 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO 31.3±0.33					·
27 50% J × HO(F2) 22±0.6 On-station Sendros et al., 2003 28 50%HF × BO 24.83±2.33 HARC/on-station Yohannes, 2017 29 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 28.6±0.94 HARC/on-station Gizachew al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Aynalem et al., 2011 32 62.5% J × BO 21.9±0.9 On-station Sendros et al., 2003 34 75% HF × BA(F1) 29.3±0.6 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Aynalem et al., 2003 36 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO F2 31.31±0.33 On-station Belay, 2014 40 75% HF × FO 26.56±0.26 MCBIR /on-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 <t< td=""><td></td><td></td><td></td><td></td><td>·</td></t<>					·
28 50%HF × BO 24.83±2.33 HARC/on-station Yohannes, 2017 29 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 28.6±0.94 HARC/on-station Gizachew al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Aynalem et al., 2011 32 62.5% J × BO 21.9±0.9 On-station Sendros et al., 2003 33 62.5% J × BO 20.7±1.13 HARC/on-station Gizachew et al., 2003 34 75% HF × Ba(F1) 29.3±0.6 On-station Sendros et al., 2003 35 75% HF × BO(F1) 29.3±0.6 On-station Aynalem et al., 2011 36 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO F2 31.3±0.33 On-station Belay, 2014 40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 200 42 75% J		` ,			
29 62.5% HF × BO 28.9±0.7 On-station Sendros et al., 2003 30 62.5% HF × BO 28.6±0.94 HARC/on-station Gizachew al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Aynalem et al., 2011 32 62.5% J × BO 21.9±0.9 On-station Gizachew et al., 2003 33 62.5% J × BO 20.7±1.13 HARC/on-station Gizachew et al., 2003 34 75% HF × Ba(F1) 29.3±0.6 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Aynalem et al., 2011 36 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO 26.56±0.26 MCBIR /on-station Fikadu, 2020 39 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 2003 42 75% J × Ba(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% HF × A 24.6±0.6 ALF/on-station Berhanu, 2008 46 75% HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 47 75% HF × BO 31.4±0.27 On-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Berhanu, 2008		, ,			
30 62.5% HF × BO 28.6±0.94 HARC/on-station Gizachew al., 2003 31 62.5% HF × BO 29.2±0.36 On-station Aynalem et al., 2011 32 62.5% J × BO 21.9±0.9 On-station Gizachew et al., 2003 33 62.5% J × BO 20.7±1.13 HARC/on-station Gizachew et al., 2003 34 75% HF × Ba(F1) 29.3±0.6 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Aynalem et al., 2011 36 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO F2 31.31±0.33 On-station Fikadu, 2020 39 75% HF × FO 26.56±0.26 MCBIR /on-station Belay, 2014 40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 2003 42 75% J × BO(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% HF × A 24.6±0.6 ALF/on-station Sendros et al., 2003 46 75% HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 47 75% HF × BO 31.4±0.27 On-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011					•
31 62.5% HF × BO 29.2±0.36 On-station Aynalem et al., 2011 32 62.5% J × BO 21.9±0.9 On-station Sendros et al., 2003 33 62.5% J × BO 20.7±1.13 HARC/on-station Gizachew et al., 2003 34 75% HF × Ba(F1) 29.3±0.6 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Aynalem et al., 2011 36 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO F2 31.31±0.33 On-station Fikadu, 2020 39 75% HF × FO 26.56±0.26 MCBIR /on-station Belay, 2014 40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 2003 42 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 43 75% J × BO 22.13±0.37 HARC/on-station Sendros et al., 2003 45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75% HF × A 24.6±0.6 ALF/on-station Sendros et al., 2003 47 75% HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011					·
32 62.5% J × BO 21.9±0.9 On-station Sendros et al., 2003 33 62.5% J × BO 20.7±1.13 HARC/on-station Gizachew et al., 2003 34 75% HF × Ba(F1) 29.3±0.6 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Aynalem et al., 2011 36 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO F2 31.31±0.33 On-station Fikadu, 2020 39 75% HF × FO 26.56±0.26 MCBIR /on-station Belay, 2014 40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Sendros et al., 2003 42 75% J × Ba(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75% HF × A 24.6±0.6 ALF/on-station Sendros et al., 2003 47 75% HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Berhanu, 2008					•
33 62.5% J × BO 20.7±1.13 HARC/on-station Gizachew et al., 2003 34 75% HF × Ba(F1) 29.3±0.6 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Aynalem et al., 2011 36 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO F2 31.31±0.33 On-station Fikadu, 2020 39 75% HF × FO 26.56±0.26 MCBIR /on-station Belay, 2014 40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 200 42 75% J × Ba(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75% HF					
34 75% HF × Ba(F1) 29.3±0.6 On-station Sendros et al., 2003 35 75% HF × BO 31.1±0.28 On-station Aynalem et al., 2011 36 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO F2 31.31±0.33 On-station Fikadu, 2020 39 75% HF × FO 26.56±0.26 MCBIR /on-station Belay, 2014 40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 200 42 75% J × Ba(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75% HF × BO 31.74±0.29 HARC/on-station Apynalem et al., 2011					,
35 75% HF × BO 31.1±0.28 On-station Aynalem et al., 2011 36 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO F2 31.31±0.33 On-station Fikadu, 2020 39 75% HF × FO 26.56±0.26 MCBIR /on-station Belay, 2014 40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 200 42 75% J × Ba(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75% HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75% HF × BO 31.74±0.29 HARC/on-station Aynalem et al., 2011					
36 75% HF × BO(F1) 29.7±0.4 On-station Sendros et al., 2003 37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO F2 31.31±0.33 On-station Fikadu, 2020 39 75% HF × FO 26.56±0.26 MCBIR /on-station Belay, 2014 40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 200 42 75% J × Ba(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75% HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75% HF × BO 31.74±0.29 HARC/on-station Aynalem et al., 2011					•
37 75% HF × BO(F2) 28.6±1.2 On-station Sendros et al., 2003 38 75% HF × BO F2 31.31±0.33 On-station Fikadu, 2020 39 75% HF × FO 26.56±0.26 MCBIR /on-station Belay, 2014 40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 200 42 75% J × Ba(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75% HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75% HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011					•
38 75% HF × BO F2 31.31±0.33 On-station Fikadu, 2020 39 75% HF × FO 26.56±0.26 MCBIR /on-station Belay, 2014 40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 200 42 75% J × Ba(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75% HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75% HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011					
39 75% HF × FO 26.56±0.26 MCBIR /on-station Belay, 2014 40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 200 42 75% J × Ba(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75% HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75% HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011		` '			•
40 75% HF × HO(F1) 28.4±0.5 On-station Sendros et al., 2003 41 75% HF × Z 25.7±0.8 ALF/on-station Abdinasir and Eskil, 200 42 75% J × Ba(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75% HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75% HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011					
41 75% HF × Z 25.7 ± 0.8 ALF/on-station Abdinasir and Eskil, 200 42 75% J × Ba(F1) 21.3 ± 0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13 ± 0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1 ± 0.5 On-station Sendros et al., 2003 45 75% J × HO(F1) 21 ± 0.5 On-station Sendros et al., 2003 46 75% HF × A 24.6 ± 0.6 ALF/on-station Abdinasir and Eskil, 20 47 75% HF × BO 31.74 ± 0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4 ± 0.27 On-station Aynalem et al., 2011					•
42 75% J × Ba(F1) 21.3±0.6 On-station Sendros et al., 2003 43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75%HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75%HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011		` ,			·
43 75% J × BO 22.13±0.37 HARC/on-station Berhanu, 2008 44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75%HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75%HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011					·
44 75% J × BO(F1) 21.1±0.5 On-station Sendros et al., 2003 45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75%HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75%HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011		, ,			•
45 75% J × HO(F1) 21±0.5 On-station Sendros et al., 2003 46 75%HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75%HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011					•
46 75%HF × A 24.6±0.6 ALF/on-station Abdinasir and Eskil, 20 47 75%HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011		, ,			,
47 75%HF × BO 31.74±0.29 HARC/on-station Berhanu, 2008 48 87.5% HF × BO 31.4±0.27 On-station Aynalem et al., 2011		` ,			•
48 87.5% HF × BO 31.4±0.27 On-station Aynalem <i>et al.</i> , 2011					•
•					·
49 87.5% HF × FO 26.45±0.73 MCBIR /on-station Belay, 2014					•
	49	87.5% HF × FO	26.45±0.73	MCBIR /on-station	Belay, 2014

Table 1: Continue...

2 Agricultural Reviews

Table	1:	Continue

50	$HF \times FO$	24.92±0.37	MCBIR	Addisu and Hegede, 2003
51	$HF \times FO$	23.5	ALRC /on-station	Addisu et al., 2010
52	$HF \times HO$	22.13±0.14	BARC/on-station	Habtamu et al., 2012
53	$J \times HO$	19.1±0.19	BARC/on-station	Habtamu et al., 2012
54	$J \times HO$	18.2±2.03	On-farm &on-station	Demissu, 2013

BW, Birth weigh; ALRC, Andassa Livestock Research Center; BARC, Bako Agricultural Research center; HARC, Holetta Agricultural Research center; MCBIR, Metekele cattle breeding and improvement Center; ALF, Assela Livestock Farm; Kg, Kilo gram; HF, Holstein Friesian; HF×BO, Holstein Friesian cross with Boran; HF×Ba, Holstein Friesian cross with Barka; HF×HO, Holstein Friesian cross with Horro; J×BO; Jersey cross with Boran; J×HO, Jersey cross with Horro; JxBa; Jersey cross with Barka; HO, Horro; BO, Boran; Ba, Barka; F1, First Generation Crossbred; F2, Second Generation Crossbred.

Table 2: Age at first service of crossbred dairy cows with different genetic group in Ethiopia.

0	•	0 0 1	
Breed/genotype	AFS (months)	Study sites	Source
50% F1 Friesian	27.0±0.45	On station	Getahun et al., 2019
50% F2 Friesian	34.8±0. 82	On station	Getahun et al., 2019
50% F3 Friesian	33.0±1.02	On station	Getahun et al., 2019
50% HF	27±0.7	On station	Haile et al., 2009
50% HF × Local	28.80±5.48	On farm	Melku, 2016
75% F1 Friesian	31.3±0.81	On station	Getahun et al., 2019
75% F2 Friesian	30.2±1.58	On station	Getahun et al., 2019
75% HF	28±0.9	On station	Haile et al., 2009
75% HF × Local	25.20±4.88	On farm	Melku, 2016
87.5% HF	28±1.2	On station	Haile et al., 2009
93.75% HF	30.5±0.60	On station	Wubshet, 2018
HF × Borena	30.47±0.85	On station	Wassie et al., 2015
HF × Borena	31.33±0.44	On station	Mengistu et al., 2016
HF × Fogera	36.8±0.8	On station	Gebeyehu et al., 2005
HF × Fogera	18.96	On farm	Sena et al., 2014
HF × Arsi	33.62±0.71	On station	Wassie et al., 2015
HF × Borena	40.9±0.33	On station	Berhanu et al., 2011
HF × Borena	26.4±0.8	On station	Yohannes et al., 2017
Horro-Jersey F1	33.3±10.90	On farm	Hunduma, 2013
Jersey × Horro	31.32±1.0	On station	Sisay, 2015

Reproductive performance traits

The lifetime productivity of a cow is influenced by its reproductive performance traits. Dessalegn *et al.* (2016) summarized that poor management of dairy cattle was the most probable factor adversely affecting the reproductive performance of cross breed cattle. Efficient heat detection and timely insemination, better health management, genetic improvement of crossbreeding, supplementing of good quality feed resources are required for optimal reproduction performance.

Age at first service (AFS)

Age at first service (AFS) is the age at which heifers attain optimum body condition and sexual maturity for accepting service for the first time. The higher age at first service resulted from the low level of management and poor feeding of calves and heifers at the earlier stages, which consequently had reduced growth rate and delayed puberty (Dessalegn *et al.*, 2016) (Table 2).

Age at first calving (AFC)

Age at first calving is the age at which heifers calve for the first time. First calving also marks the beginning of

Volume Issue 3

Table 3: Age at first calving of crossbred dairy cows with different genetic group in Ethiopia.

Breed/genotype	AFC (months)	Study sites	Source
50% F1 Friesian	37.0±0.47	On station	Getahun et al, 2019
50% F2 Friesian	44.6±0.87	On station	Getahun et al, 2019
50% F3 Friesian	44.5±1.08	On station	Getahun et al, 2019
50% HF	39±0.6	On station	Haile et al., 2009
50% HF × Local	39.72±6.04	On farm	Melku, 2016
50% F1 Friesian	39.61	On station	Tadesse, 2014
50% F2 Friesian	46.25	On station	Tadesse, 2014
50% F3 Friesian	47.23	On station	Tadesse, 2014
50% Friesian × Arsi (F1)	29.2±1.4	On station	Negussie et al. 1998
50% HF × local (F1)	43.77±4.2	On station	Million et al., 2006
50% HF × local (F2)	35.91±1.3	On station	Million et al., 2006
50% HF × local (F3)	41.91±1.8	On station	Million et al., 2006
50% Jersey × Arsi (F1)	28.5±1.3	On station	Negussie et al. 1998
50% Jersey × Borena (F1)	46.91±3.8	On station	Million et al., 2006
50% Jersey × Borena (F2)	34.25±4.6	On station	Million et al., 2006
50% Jersey × local (F1)	45.32±2.7	On station	Million et al., 2006
75% F1 Friesian	42.4±0.85	On station	Getahun et al, 2019
75% F2 Friesian	39.9±1.66	On station	Getahun et al, 2019
75% Friesian	41.29±9	On station	Kefena et al., 2006
75% HF	40±0.9	On station	Haile et al., 2009
75% HF × Local	36.36±4.56	On farm	Melku, 2016
75% Jersey	42.52±5	On station	Kefena et al., 2006
75% HF × Borena	46.46	On station	Tadesse, 2014
75% HF × local (F1)	45.60±2.6	On station	Million et al., 2006
75% HF × local (F2)	40.77±1.2	On station	Million et al., 2006
87.5% HF	39±1.3	On station	Haile et al., 2009
93.75% HF	39.76±0.67	On station	Wubsh et al., 2018
F1 Friesian	42.35±9	On station	Kefena et al., 2006
F1 Jersey	39.50±8	On station	Kefena et al., 2006
F2 Friesian	48.56±5	On station	Kefena et al., 2006
F2 Jersey	44.07±5	On station	Kefena et al., 2006
HF × Arsi	42.84±0.84	On station	Wassie et al., 2015
HF × Borena	39.49±0.83	On station	Wassie et al., 2015
HF × Borena	41.08±0.44	On station	Mengistu et al., 2016
HF × Fogera	29.52	On farm	Sena et al., 2014
HF × Local	38.8±0.5	On station	Negussie et al. 1999
$HF \times (Jersey \times Arsi)$	35.2±0.9	On station	Negussie et al. 1999
Jersey × GH	48.57±1.89	On farm	Wondossen et al., 2018
Jersey × Horro	42.2±11.45	On farm	Hunduma, 2013
Jersey × Horro	42.02±1.1	On station	Sisay, 2015

a cow's productive life. Age at first calving is closely related to generation interval and, therefore, influences response to selection (Abdel Rahman and Alemam, 2008) (Table 3).

CONCLUSION

It is concluded that by improving the management system such as efficient heat detection and timely insemination, better health management, genetic improvement of crossbreeding and supplementing of good quality and quantity of feed resources are required for optimal early growth and reproductive performance. It is possible to improve the growth and reproductive performances of the crossbred dairy cattle in the country. On station and on farm production system should developed and implement complete records including identity, performance, health care and production recording schemes. Selection and culling criteria should be defined on the bases of growth and reproductive performance of cows.

4 Agricultural Reviews

Conflict of interest

The authors declare that no conflict of interest concerning the research review or authorship of this research review article.

REFERENCES

- Ababu, D., Ayalew, W., Hedge, P.B. and Taddese, Z. (2006). Performance of the abernosa ranch in the production of Ethiopian Boran × Holstein crossbreed dairy heifers in Ethiopia. Eth. J. Anim. Prod. 6(1): 33-53.
- Abdel, R.I.M.K. and Alemam, T.A. (2008). Reproductive and productive performance of holstein-friesian cattle under tropical conditions with special reference to sudan-A review. Agric. Rev. 29(1): 68-73.
- Abdinasir, I. and Brannang, E. (2001). Growth performance of crossbred dairy cattle at Asella livestock farm, Arsi, Ethiopia. Ethiop. J. Sci. 24(1): 35-49.
- Addisu, B. and Hegede, B.P. (2003). Reproductive and Growth Performance of Fogera Cattle and their F1 Friesian Crosses at Metekel Ranch, Ethiopia: In: Challenges and Opportunities of Livestock Marketing in Ethiopia. [Jobre, Y. and Gebru, G. (Eds)], Proc. 10th Annual Conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 22-24, 2002. ESAP, Addis Ababa. pp. 119-126.
- Addisu, B., Taye, M., Kebede, A., Mekuriaw, G., Tassew, A., Mulugeta, T. and Goshu, G. (2010). Milk yield and calf growth performance of cattle under partial suckling system at andassa livestock research centre, North West Ethiopia. Livestock Research for Rural Development. 22(8).
- Aynalem H., Joshi1, B.K., Ayalew, W., Tegegne, A. and Singh, A. (2011). Genetic evaluation of Ethiopian boran cattle and their crosses with holstein friesian for growth performance in central Ethiopia. J. Anim. Breed. Genet. 128: 133-140.
- Belay, Z. (2014). Estimation of Genetic Parameters for Growth and Reproductive Traits of Fogera and Holstein Friesian Crossbred Cattle at Metekel Ranch, Amhara Region, Ethiopia: Msc. Thesis. Haramaya University, Ethiopia, 111PP.
- Berhanu, B. (2008). Genetic Evaluation of Dairy Cattle Sires in Central Highlands of Ethiopia. Doctor of Philosophy (PhD) Dissertation, Deemed University, Haryana, India. Pp. 328.
- Berhanu, Y., Lobago, F. and Goshu, G. (2011). Calf survival and reproductive performance of Holstein-Friesian cows in Central Ethiopia. Tropical Animal Health and Production. 43: 359-365.
- CSA (Central Statistical Agency) Federal Democratic Republic of Ethiopia. (2020/2021). Agricultural Sample Survey Report on Livestock and Livestock Characteristics (Private Peasant Holdings). Addis Ababa, Ethiopia.
- Demissu, H., Beyene, F. and Duguma, G. (2013). Early growth and reproductive performances of horro cattle and their F1 jersey crosses in and around horro guduru livestock production and research Center, Ethiopia. Sci. Technol. Arts Res. J. 2(3): 134-141.

- Dessalegn, G., Tamir, B. and Berhane, G. (2016). Study of reproductive and production performance of cross breed dairy cattle under smallholder's management system in bishoftu and akaki towns. Global Journal of Animal Science, Livestock Production and Animal Breeding. 4(1): 243-247.
- Fikadu, W. (2020). Phenotypic and genetic parameters estimation for growth traits of Holstein Friesian × Boran crossbred dairy cattle at Holletta agricultural research center, Ethiopia. MSc Thesis, Bahir Dar University, Baihir Dar, Ethiopia, 109 Pp.
- Fikre, L., Bekana, M., Gustafsson, H. and Kindahl, H. (2007). Longitudinal observation on reproductive and lactation performances of smallholder crossbred dairy cattle in Fitche, Oromia Region, Central Ethiopia. Tropical Animal Health and Production. 39: 395-403.
- Gebeyehu, G., Asmare, A. and Asseged, B. (2005). Reproductive performances of Fogera cattle and their Friesian crosses in Andassa ranch, Northwest Ethiopia. Livestock Research for Rural Development. 17(12): 131. ISSN: 0121-3784.
- Getahun, K., Hunde, D., Tadesse, M. and Tadesse, Y. (2019).

 Reproductive performances of crossbred dairy cattle at
 Holetta Agricultural Research Center. Livestock Research
 for Rural Development. 31, Article #138. Retrieved June
 29, 2023, from http://www.lrrd.org/lrrd31/9/kefa31138.html.
- Gizachew, B., Yielma, Z., Bekele, T., G/wold, A., Demeke, S., Gojjam, Y. and H/Silassie, R. (2003). Performance of Two and Three Way Crossbred Dairy Cattle at Holetta Research Center in Central Highlands of Ethiopia: Growth Rate: In: Challenges and Opportunities of Livestock Marketing in Ethiopia. [Jobre, Y. and Gebru, G. (Eds)], Proc. 10th Annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 22-24, 2002. ESAP, Addis Ababa. pp. 127-130.
- Habtamu, A., Abegaz, S. and Mekasha, Y. (2012). Influence of non-genetic factors on growth traits of Horro (Zebu) and their crosses with Holstein Friesian and Jersey cattle. Academic Journals. International Journal of Livestock Production. 3(7): 72-77.
- Haile, A., Joshi, B.K., Ayalew, W., Tegegne, A. and Singh, A. (2009). Genetic evaluation of Ethiopian Borena cattle and their crosses with Holstein Friesian in central Ethiopia: Reproductive traits. Journal of Agricultural Science. 147: 81-89.
- Hunduma, D. (2013). Reproductive performance of crossbred dairy cows under smallholder condition in Ethiopia. African Journal of Dairy Farming and Milk Production (AJDFMP). 1: 101-103.
- Kefena, E., Kumsa, T. and Gojjam, Y. (2006). Review of the Performance of Crossbred Dairy Cattle in Ethiopia. In: Proceedings of the 14th Annual Conference of the Ethiopian Society of Animal Production, 5-7 September 2006. [Degefa, T. and Feyissa, F. (Eds)], ESAP (Ethiopian Society of Animal Production), Addis Ababa, Ethiopia. Pp 191-199.
- Melku, M. (2016). Milk Production and Reproduction Performance of Local and Crossbreed Dairy Cows in Selected Districts of West Gojam Zone, Amhara Region. M.Sc. Thesis, Bahir Dar University, Bahir Dar, Ethiopia.149 Pp.

Volume Issue 5

- Mengistu, W.D., Wondimagegn, K.A. and Demisash, M.H. (2016). Reproductive performance evaluation of Holstein Friesian and their crosses with Borena cattle breeds in ardaita agricultural technical vocational education training college dairy farm, Oromia Region, Ethiopia. Iranian Journal of Applied Animal Science. 6(4): 805-814.
- Million, T., Dessie, T., Tessema, G., Degefa, T. and Gojam, Y. (2006). Study on age at first calving, calving interval and breeding efficiency of bos taurus, bos indicus and their crosses in the highlands of Ethiopia. Ethiopian Journal of Animal Production. 6(2): 1-16.
- Negussie, E.E., Brannang and Rottmann, O.J. (1999). Reproductive performance and herd life of dairy cattle at Asella livestock farm, Arsi, Ethiopia. Crossbreds with 50, 75 and 87.5% European inheritance. Journal of Animal Breeding and Genetics. 116: 225-234.
- Negussie, E.E., Banjaw, B.K. and Rottmann, O.J. (1998). Reproductive performance of dairy cattle at Asella livestock farm, Arsi, Ethiopia. I: Indigenous cows versus their F1 crosses. Journal of Animal Breeding and Genetics. 115: 267-280.
- Sena, T., Gueshfesaha, Abebe, A., Hailu, B. and Dejen, W. (2014). Assessment of productive and reproductive performances of cross breed dairy cows in debre tabor town. Biology Agriculture and Healthcare. 4: 112-116.
- Sendros, D., Neser, F.W.C. and Schoeman, S.J. (2003). Early growth performance of Bos Taurus × Bos indicus cattle crosses in Ethiopia: Evaluation of different crossbreeding models. J. Anim. Breed. Genet. 120: 39-50.

- Sisay, E. (2015). Productive and Reproductive Performance of Dairy Cows (Horro, Horro × Friesian and Horro × Jersey) at Bako Agricultural Research Center. MSc Thesis, Haramaya University, Haramaya, Ethiopia.
- Tadesse, B. (2014). Estimation of Crossbreeding Parameters in Holstein Friesian and Ethiopian Boran Crosses for Milk Production and Reproduction Traits at Holeta Agricultural Research Center. MSc Thesis. Haramaya University, Haramaya, Ethiopia. 83 Pp.
- Wassie, T., Mekuriaw, G. and Mekuriaw, Z. (2015). Reproductive performance for Holstein Friesian × Arsi and Holstein Friesian × Borena crossbred cattle. Iranian Journal of Applied Animal Science. 5(1): 35-40.
- Wondossen, A., Mohammed, A. and Negussie, E. (2018). Reproductive performance of Holstein Friesian dairy cows in a tropical highland environment. Journal of Advances in Dairy Research. 6(2): 203. DOI: 10.4172/2329-888X.1000203.
- Wubshet, K. (2018). Estimation of Genetic and Non-Genetic Parameters for Reproduction and Production Traits of Holstein Friesian Dairy Herd at ELFORA Cheffa Dairy Farm, Oromia Zone of Amhara Region. MSc Thesis, Haramaya University, Haramaya, Ethiopia. 93 Pp.
- Yohannes, G., Tadesse, M., Efffa, K. and Hunde, D. (2017). Performance of crossbred dairy cows suitable for smallholder production systems at holetta agricultural research centre. Ethiop. J. Agric. Sci. 27(1): 121-131.

6 Agricultural Reviews