The Astrophysical Journal, 863:91 (22pp), 2018 August 10 https://doi.org/10.3847/1538-4357/aac76e

New and Known Moving Groups and Clusters Identified in a *Gaia* Comoving Catalog

Jacqueline K Faherty[1], John J. Bochanski[2], Jonathan Gagné[3], Olivia Nelson[1], Kristina Coker[1], Iliya Smithka[1], Deion Desir[1], and Chelsea Vasquez[1]
[1] American Museum of Natural History Department of Astrophysics, Central Park West at 79th Street, New York, NY 10034, USA; jfaherty@amnh.org
[2] Rider University, 2083 Lawrenceville Road, Lawrenceville, NJ 08648, USA
[3] Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015, USA
Received 2018 March 25; revised 2018 May 8; accepted 2018 May 10; published 2018 August 13

Abstract

We present a reorganization of the Oh et al. wide, comoving catalog of 4555 groups of stars (10,606 individual objects) identified in the Tycho Gaia Astrometric Survey (TGAS) into new and known coevolving groups of stars in the Milky Way. We use the BANYAN Σ kinematic analysis tool to identify 1015 individual stars in the Oh et al. catalog that yielded a >80% probability in 1 of 27 known associations (e.g., the AB Doradus moving group, Columba, Upper Scorpius) in the vicinity of the Sun. Among the 27 groups uncovered by Oh et al. that had >10 connected components, we find that 4 are newly discovered. We use a combination of Tycho, *Gaia*, Two micron All Sky catalog, *Wide Field Infrared Survey Explorer Mission*, *Galaxy Evolution Explorer*, and *Rontgen Satellite* photometry as well as *Gaia* parallaxes to determine that these new groups are likely older than the Pleiades but younger than ~1 Gyr. Using isochrone fitting, we find that the majority of these new groups have solar-type stars and solar-type metallicity. Among the 35 Oh et al. groups with five to nine members, we find that 19 also appear new and comoving, with Oh et al. Group 30 is particularly exciting as it is well within 100 pc (range of 77–90 pc) and also appears to be older than the Pleiades. For known star-forming regions, open clusters, and moving groups identified by Oh et al., we find that the majority were broken up into pieces over several Oh et al. groups (e.g., Lower Centaurus Crux members are spread over 26 Oh et al. groups); however, we found no correlation with positions of the groups on color–magnitude diagrams, and therefore no substructure of the association correlated with the Oh et al. designated group. We find that across the 27 groups tested by BANYAN Σ there were 400 new members to 20 different associations uncovered by Oh et al. that require further vetting.

Key words: methods: data analysis – proper motions – stars: kinematics and dynamics – open clusters and associations: general – binaries: general

Supporting material: machine-readable tables

1. Introduction

Mapping the Milky Way with coevolving stars can provide information on the dynamic history of our Galaxy. Galactic position along with parallax, proper motion, and radial velocity measurements for individual stars helps us to create maps of the six-dimensional spatial and velocity structure of the Milky Way. Using such detailed maps of the Galaxy, investigations of the locations of stars with their kinematic clustering can be paired with parameters such as stellar separations, fundamental parameter estimates (log (g), metallicity, mass, and radius), and chemical compositions to yield vital details about the past, present, and future of the Milky Way.

Widely separated companions are particularly important as they are easiest to study in detail given that individual sources can be resolved. Studying binaries, triples, or hierarchical systems with common origins, allows for much needed tests on age-calibration relations (e.g., Chanamé & Ramírez 2012) but can also lead to intriguing discoveries about the planetary formation history around Milky Way stars (e.g., Teske et al. 2015; Oh et al. 2018). Furthermore, hierarchical systems at wide separations that have strong evidence for coevolution are important objects for understanding the influence of the Galactic potential and large perturber structures (e.g., giant molecular clouds) in the Milky Way (e.g., Weinberg et al. 1987).

The Washington Double Star Catalog (WDS) maintained by the United States Naval Observatory is a principal resource for a list of double and multiple star information (Mason et al. 2018) and contains over 140,000 entries with references for discovery as far back as 1895 (e.g., Aitken 1895). Currently, identifying widely separated companions is enabled by large or all-sky surveys such as the Sloan Digital Sky Survey (e.g., Dhital et al. 2010, 2015), the Digitized Sky Surveys (e.g., Lépine 2005; Lépine & Shara 2005), Tycho, and *Hipparcos* (e.g., Kirkpatrick et al. 2001; Faherty et al. 2010, 2011). Having precise parallax, proper motion, and radial velocity are critical to identifying and confirming comoving stars. That is why the European Space Agency's (ESA) *Gaia* space-based observatory is a much-anticipated next major advancement in the science enabled by wide comoving stars. By the time of the *Gaia* DR2 release (expected in 2018 April), this mission will chart 10,000 times more stars than *Hipparcos* at a precision 100 times better. In 2016 September, the first data release of *Gaia* (DR1), which provided a subset of parallaxes and precise proper motions for Tycho stars (dubbed TGAS) led to several papers identifying new wide hierarchical systems in the Galaxy (e.g., Andrews et al. 2017; Oelkers et al. 2017; Oh et al. 2017, hereafter Oh17).

Aside from wide binaries in the Galaxy, important comoving collections of moderate numbers of stars have also been

Table 1
Oh17 with Spectral Type and $T_{\rm eff}$

Name (1)	R.A. (2)	Decl. (3)	SpT (4)	$T_{\rm eff}$ (K) (5)	BANYAN Grp (6)	BANYAN Prob[a] (%) (7)	Oh Grp (8)
TYC 1253-388-1	59.45728	18.56219	⋯	⋯	FIELD	7.3	0
TYC 1804-1924-1	57.07039	25.21493	F4V	6890	PLE	98.7	0
HIP 18091	58.00344	19.59669	⋯	⋯	FIELD	36.6	0
HIP 18544	59.50715	20.6766	F8	6200	PLE	56.9	0
TYC 1261-1630-1	58.37032	20.90718	⋯	⋯	PLE	98.7	0
TYC 1261-1415-1	58.88317	21.07928	⋯	⋯	PLE	79.1	0
TYC 1261-24-1	59.59016	21.25748	⋯	⋯	PLE	95.2	0
HIP 18266	58.61605	21.38955	⋯	⋯	PLE	98.6	0
HIP 19367	62.23086	20.38579	F8	6200	FIELD	0.3	0
HIP 18955	60.93413	22.9441	F5	6440	PLE	75.2	0
HIP 16423	52.8682	21.82172	F2	6890	PLE	85.6	0
HIP 15341	49.45743	22.832	A3	8720	FIELD	0.2	0
TYC 1256-516-1	56.25702	19.55919	F5	6440	PLE	65.8	0
HIP 17325	55.62454	20.1498	A2	8970	PLE	94.3	0
HIP 17607	56.58068	20.8796	⋯	⋯	PLE	99.1	0
TYC 1260-671-1	57.16395	21.92476	F0	7200	PLE	96.2	0
HIP 17921	57.47955	22.24397	B8III	12400	PLE	99.8	0
HIP 17892	57.40917	22.5333	B9	10500	PLE	99.8	0
TYC 1800-118-1	57.297	22.60927	A0	9520	PLE	99.8	0
TYC 1800-669-1	57.58886	23.09616	⋯	⋯	PLE	99.9	0
HIP 17043	54.8051	21.84306	A0	9520	PLE	99.3	0
HIP 17316	55.60007	21.47329	G0	6030	PLE	99.1	0
TYC 1247-515-1	55.8798	22.15819	F8	6200	PLE	99.8	0
HIP 17317	55.60019	22.42095	⋯	⋯	PLE	99.9	0
HIP 17511	56.2456	22.03227	F5	6440	PLE	99.7	0
TYC 1260-498-1	56.17434	22.46436	⋯	⋯	PLE	99.4	0
TYC 1799-1102-1	56.41633	22.69428	A0	9520	PLE	99.9	0
TYC 1800-1574-1	56.66006	22.9196	G0	6030	PLE	99.9	0
HIP 17497	56.21357	23.26874	F3V	6890	PLE	99.9	0
TYC 1800-1774-1	56.69618	22.91439	F8	6200	PLE	99.9	0
TYC 1800-2170-1	56.95058	23.2179	⋯	⋯	PLE	99.9	0
TYC 1800-471-1	57.48549	23.21844	F8	6200	PLE	99.7	0
TYC 1800-496-1	57.41426	23.28992	⋯	⋯	PLE	99.9	0
TYC 1800-628-1	57.4206	23.34138	A7V	7850	PLE	99.9	0
TYC 1800-727-1	57.38645	23.38022	F3V	6890	PLE	99.9	0
TYC 1800-2129-1	57.18299	23.25963	A8V	7850	PLE	100	0
TYC 1800-1672-1	56.66674	23.11014	F5V	6440	PLE	99.9	0
HIP 17572	56.45349	23.14696	A0	9520	PLE	99.9	0
TYC 1800-1917-1	56.54194	23.3398	⋯	⋯	PLE	99.2	0
TYC 1800-2027-1	56.756	23.49475	⋯	⋯	PLE	99.9	0
TYC 1800-1616-1	56.72404	23.58337	⋯	⋯	PLE	99.9	0
TYC 1800-1630-1	56.86188	23.67814	A3V	8720	PLE	99.8	0
HIP 17692	56.83746	23.80315	A1V	9230	PLE	99.9	0

Notes. This subtable is a preview of the entire sample, which will be available as a machine-readable table. Above we show the Tycho or *Hipparcos* name along with corresponding position, and the SpT and $T_{\rm eff}$ compiled in Skiff (2014). We also show the BANYAN Σ probability of membership and the corresponding group as well as the Oh17 group number.

[a] The BANYAN probability is applicable for the group noted.

(This table is available in its entirety in machine-readable form.)

discovered using astrometric surveys. Using early, low astrometric precision catalogs, Kapteyn (1905) and Eggen (1965) identified large kinematically coherent associations of stars through their common proper motions and parallaxes. With time, astrometric surveys became far more precise and these original associations were resolved into smaller age-coherent groups with the progression to milliarcsecond parallaxes and proper motions from the Tycho and *Hipparcos* surveys (Perryman et al. 1997; Høg et al. 2000).

Within a few hundred parsecs of the Sun, there are numerous associations ranging in age from a few megayears (e.g., Rho Ophiuchus, 0.5–2 Myr, Wilking et al. 2008; Taurus, 1–2 Myr, Daemgen et al. 2015) to hundreds of megayears (e.g., Tucana Horologium, ∼45 Myr; AB Doradus, ∼150 Myr, Bell et al. 2015; Pleiades, ∼112 Myr, Dahm 2015; Hyades, ∼750 Myr, Brandt & Huang 2015a). In-depth studies of the closest associations to the Sun (<200 pc) have revealed that they harbor large numbers of low-mass stars, brown dwarfs, and even objects whose mass falls below the deuterium burning boundary (so-called free-floating planetary-mass objects; Gagné et al. 2015; Faherty et al. 2016). Moreover, given that moving groups harbor the closest young stars to the Sun, they

Table 2
Oh17 with Photometry

Name (1)	SpT (2)	*B* (3)	*V* (4)	*J* (5)	*H* (6)	*K* (7)	*W*1 (8)	*W*2 (9)	*W*3 (10)	*W*4 (11)
TYC 1253-388-1	⋯	12.45	11.32	9.98 ± 0.03	9.53 ± 0.02	9.45 ± 0.02	9.38 ± 0.02	9.41 ± 0.02	9.27 ± 0.05	8.63 ± ⋯
TYC 1804-1924-1	F4V	9.62	9.22	8.14 ± 0.02	7.91 ± 0.02	7.86 ± 0.02	7.83 ± 0.03	7.86 ± 0.02	7.82 ± 0.02	7.33 ± 0.12
HIP 18091	⋯	11.13	10.45	9.27 ± 0.02	8.98 ± 0.02	8.87 ± 0.02	8.86 ± 0.02	8.88 ± 0.02	8.82 ± 0.03	8.23 ± 0.33
HIP 18544	F8	9.88	9.38	8.44 ± 0.02	8.25 ± 0.02	8.20 ± 0.03	8.13 ± 0.02	8.15 ± 0.02	8.14 ± 0.02	7.79 ± 0.20
TYC 1261-1630-1	⋯	12.86	11.68	10.10 ± 0.02	9.64 ± 0.02	9.51 ± 0.02	9.48 ± 0.02	9.49 ± 0.02	9.39 ± 0.04	8.79 ± ⋯
TYC 1261-1415-1	⋯	11.79	11.11	9.62 ± 0.02	9.28 ± 0.02	9.17 ± 0.02	9.14 ± 0.02	9.19 ± 0.02	9.16 ± 0.03	8.27 ± ⋯
TYC 1261-24-1	⋯	12.35	11.42	9.94 ± 0.03	9.58 ± 0.03	9.45 ± 0.02	9.42 ± 0.02	9.45 ± 0.02	9.35 ± 0.04	8.75 ± ⋯
HIP 18266	⋯	11.65	10.85	9.60 ± 0.02	9.26 ± 0.02	9.18 ± 0.02	9.16 ± 0.02	9.20 ± 0.02	9.16 ± 0.03	8.26 ± 0.32
HIP 19367	F8	9.83	9.36	8.38 ± 0.02	8.19 ± 0.02	8.11 ± 0.03	8.11 ± 0.02	8.13 ± 0.02	8.10 ± 0.02	8.16 ± 0.28
HIP 18955	F5	10.3	9.68	8.52 ± 0.04	8.26 ± 0.02	8.18 ± 0.02	8.16 ± 0.02	8.17 ± 0.02	8.17 ± 0.02	8.13 ± 0.28
HIP 16423	F2	9.24	8.84	8.07 ± 0.02	7.89 ± 0.02	7.82 ± 0.02	7.81 ± 0.03	7.84 ± 0.02	7.79 ± 0.02	7.71 ± 0.18
HIP 15341	A3	7.91	7.63	7.07 ± 0.02	6.98 ± 0.03	6.89 ± 0.01	6.90 ± 0.06	6.89 ± 0.02	6.92 ± 0.02	6.78 ± 0.09
TYC 1256-516-1	F5	9.87	9.39	8.40 ± 0.02	8.23 ± 0.03	8.15 ± 0.02	8.10 ± 0.02	8.11 ± 0.02	8.09 ± 0.02	7.85 ± 0.23
HIP 17325	A2	8.72	8.4	7.75 ± 0.02	7.67 ± 0.02	7.65 ± 0.02	7.74 ± 0.22	7.61 ± 0.02	7.62 ± 0.02	7.81 ± 0.19
HIP 17607	⋯	12.84	11.64	9.99 ± 0.02	9.61 ± 0.02	9.52 ± 0.02	9.47 ± 0.02	9.50 ± 0.02	9.46 ± 0.05	8.56 ± ⋯
TYC 1260-671-1	F0	8.79	8.41	7.56 ± 0.03	7.40 ± 0.02	7.32 ± 0.02	7.26 ± 0.04	7.30 ± 0.02	7.31 ± 0.02	7.25 ± 0.12
HIP 17921	B8III	6.05	6.07	5.97 ± 0.02	6.05 ± 0.06	5.98 ± 0.02	6.06 ± 0.09	5.99 ± 0.04	6.11 ± 0.01	5.70 ± 0.04
HIP 17892	B9	7.04	7	6.85 ± 0.02	6.92 ± 0.02	6.88 ± 0.02	6.89 ± 0.06	6.92 ± 0.02	6.95 ± 0.02	6.80 ± 0.08
TYC 1800-118-1	A0	7.9	7.73	7.31 ± 0.03	7.27 ± 0.03	7.24 ± 0.02	7.21 ± 0.05	7.24 ± 0.02	7.29 ± 0.02	6.92 ± 0.10
TYC 1800-669-1	⋯	12.24	11.24	9.86 ± 0.02	9.51 ± 0.03	9.39 ± 0.02	9.35 ± 0.02	9.39 ± 0.02	9.31 ± 0.04	8.25 ± ⋯

Note. This subtable is a preview of the entire sample, which will be available as a machine-readable table. Above we show the Tycho or *Hipparcos* name along with corresponding photometry from Tycho, 2MASS, and WISE as well as the SpT compiled from Skiff (2014). Upper limits on photometry are shown as ± –.

(This table is available in its entirety in machine-readable form.)

are also the targeting ground for directly imaged exoplanets. Associations such as Tucana Horologium, TW Hya, and the AB Doradus moving group contain isolated objects that range in mass from a few solar masses down to a few Jupiter masses (Gagné et al. 2017; J. K. Faherty 2018, in preparation) as well as stars with planetary-mass companions. Observations of these associations enable investigations of the mass function, kinematics, and spatial distribution across the full range of objects generated through star formation processes in different isolated groups at young (1–2 Myr), medium (30–50 Myr), and older (100–700 Myr) ages.

Given the expectation of a dramatic increase in high precision astrometry for stars in the Galaxy with *Gaia*, the DR2 catalog will reorganize our understanding of structures in the local Galactic neighborhood (e.g., Kushniruk et al. 2017). In this work, we examine the recent catalog of comoving stars produced by Oh et al. (2017) in search of new higher order structures in the Milky Way. In Section 2, we discuss the sample at large and, in Section 3, we detail all the data we collected on individual sources. In Section 4, we describe in detail our reorganization of the original catalog into known and new structures in the Galaxy using (primarily) the kinematic analysis tool called BANYAN Σ. In Section 5, we focus on five new associations that appear to be newly identified and, in Section 6, we review the age, mass, and metallicity parameters for each of them calculated using isochronal fitting. Conclusions are presented in Section 7.

2. The Sample

In 2016 September, the European Space Agency (ESA) made public the first data release catalog (DR1), including a subset dubbed the Tycho *Gaia* Astrometric Survey (TGAS; Lindegren et al. 2016). The latter contains parallaxes and proper motions for 2,057,050 stars with astrometry grounded by positions in the Tycho-2 catalog (Høg et al. 2000). While there are numerous comoving stars uncovered with the original *Hipparcos* and Tycho catalogs (e.g., Lépine & Bongiorno 2007; Faherty et al. 2010; Shaya & Olling 2011), the precision and photometric reach of *Gaia* lends itself to searches for wider and more distant pairs than has been previously possible. Indeed since the release of TGAS, several papers have conducted new analyses for wide comoving pairs (Andrews et al. 2017, 2018; Oelkers et al. 2017; Oh et al. 2017) that have pushed both the distance (separations $\gg$1 pc) and magnitude of proper motion for the discovered system.

In this paper, we use the work of Oh et al. (2017) as our input sample. Oh et al. (2017) restricted the TGAS sample to those stars with parallax signal-to-noise values $\geqslant$8 (totaling 619,618) and searched within a 10 pc radius of each for a comoving companion. Using both parallax and proper motion values of this precise subsample of TGAS stars, Oh et al. (2017) implemented a marginalized likelihood ratio test to discriminate candidate comoving pairs from the field population. Unlike the standard method for identifying comovers with a proper motion cut (e.g., recent work by Oelkers et al. 2017 that uncovered ∼1900 pairs in TGAS), the Oh et al. (2017) technique marginalized over the (unknown) true distances and velocities of the stars utilizing a probabilistic model for the assumptions on the 3D velocities of the two stars in a pair.

The outcome of the Oh et al. (2017) work is by no means a complete overview of wide, *Gaia* comovers. Indeed, between the Oelkers et al. (2017), Andrews et al. (2017), and Oh et al. (2017) wide companion catalogs from TGAS astrometry, there is overlap but also unique collections in each. Interesting for this work, Oh et al. (2017) uncovered 10,606 unique stars found to be comoving with at least one but up to 151 others in TGAS (referred to as Oh17 sample from here-in). In the process and perhaps quite serendipitously for the project,

Table 3
Oh17 with Photometry (continued)

Name (TGAS) (1)	SpT (2)	NUV (*GALEX*) (3)	FUV (*GALEX*) (4)	Name (*ROSAT* Bright) (5)	$\log(L_x)$ (*ROSAT*) (6)	Name (*ROSAT* Faint) (7)	$\log(L_x)$ (*ROSAT*) (8)	Grp (9)	BANYAN (10)
TYC 1253-388-1	⋯	17.86 ± 0.04	⋯	⋯	⋯	⋯	⋯	0	FIELD 7.3
TYC 1804-1924-1	F4V	13.48 ± 0.01	⋯	⋯	⋯	⋯	⋯	0	PLE 98.7
HIP 18091	⋯	15.48 ± 0.01	⋯	⋯	⋯	⋯	⋯	0	FIELD 36.6
HIP 18544	F8	13.69 ± 0.01	18.75 ± 0.10	⋯	⋯	⋯	⋯	0	PLE 56.9
TYC 1261-1630-1	⋯	18.22 ± 0.03	21.79 ± 0.48	⋯	⋯	035328.8 + 20544	29.94 ± 0.38	0	PLE 98.7
TYC 1261-1415-1	⋯	17.18 ± 0.03	⋯	⋯	⋯	035531.7 + 21044	29.59 ± 0.50	0	PLE 79.1
TYC 1261-24-1	⋯	17.70 ± 0.03	⋯	⋯	⋯	⋯	⋯	0	PLE 95.2
HIP 18266	⋯	16.72 ± 0.03	⋯	⋯	⋯	⋯	⋯	0	PLE 98.6
HIP 19367	F8	14.01 ± 0.00	18.87 ± 0.07	⋯	⋯	040857.0 + 20232	29.82 ± 0.40	0	FIELD 0.3
HIP 18955	F5	14.32 ± 0.01	20.02 ± 0.17	⋯	⋯	⋯	⋯	0	PLE 75.2
HIP 16423	F2	⋯	17.64 ± 0.08	⋯	⋯	⋯	⋯	0	PLE 85.6
HIP 15341	A3	12.32 ± 0.00	14.51 ± 0.01	⋯	⋯	⋯	⋯	0	FIELD 0.2
TYC 1256-516-1	F5	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 65.8
HIP 17325	A2	12.53 ± 0.00	⋯	⋯	⋯	⋯	⋯	0	PLE 94.3
HIP 17607	⋯	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.1
TYC 1260-671-1	F0	12.72 ± 0.00	⋯	034839.3 + 21553	30.03 ± 0.26	⋯	⋯	0	PLE 96.2
HIP 17921	B8III	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.8
HIP 17892	B9	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.8
TYC 1800-118-1	A0	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.8
TYC 1800-669-1	⋯	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9
HIP 17043	A0	11.64 ± 0.00	⋯	⋯	⋯	⋯	⋯	0	PLE 99.3
HIP 17316	G0	14.54 ± 0.01	⋯	⋯	⋯	⋯	⋯	0	PLE 99.1
TYC 1247-515-1	F8	15.56 ± 0.01	⋯	⋯	⋯	⋯	⋯	0	PLE 99.8
HIP 17317	⋯	15.25 ± 0.01	20.82 ± 0.16	⋯	⋯	⋯	⋯	0	PLE 99.9
HIP 17511	F5	13.70 ± 0.00	19.06 ± 0.03	⋯	⋯	⋯	⋯	0	PLE 99.7
TYC 1260-498-1	⋯	16.44 ± 0.00	21.84 ± 0.28	⋯	⋯	034440.7 + 22274	29.74 ± 0.57	0	PLE 99.4
TYC 1799-1102-1	A0	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9
TYC 1800-1574-1	G0	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9
HIP 17497	F3V	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9
TYC 1800-1774-1	F8	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9
TYC 1800-2170-1	⋯	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9
TYC 1800-471-1	F8	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.7
TYC 1800-496-1	⋯	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9
TYC 1800-628-1	A7V	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9
TYC 1800-727-1	F3V	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9
TYC 1800-2129-1	A8V	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 100
TYC 1800-1672-1	F5V	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9
HIP 17572	A0	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9
TYC 1800-1917-1	⋯	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.2
TYC 1800-2027-1	⋯	⋯	⋯	⋯	⋯	⋯	⋯	0	PLE 99.9

Note. This subtable is a preview of the entire sample, which will be available as a machine-readable table. Above we show the Tycho or *Hipparcos* name along with corresponding photometry from Galex and X-ray luminosity from *ROSAT* bright and/or faint (with corresponding name). We also include the Oh17 group number and the BANYAN Σ predicted association.

(This table is available in its entirety in machine-readable form.)

Table 4
Oh17 Sample with BANYAN Σ Input of Known Members

Name (1)	R.A. (2)	Decl. (3)	μ_α cos (δ) (mas $^{-1}$) (4)	μ_δ (mas $^{-1}$) (5)	π (mas) (6)	v_{rad} (km s^{-1}) (7)	Group-BANYAN (8)	Prob (9)	Group-Oh (10)	Known (11)	Known (12)
TYC2899-1744-1	76.17226	40.39956	12.147 ± 2.195	−111.141 ± 1.942	16.238 ± 0.262	⋯	ABDMG	92.6	1036	No	No
HIP23399	75.43895	42.34373	17.984 ± 0.076	−123.319 ± 0.052	17.337 ± 0.285	⋯	ABDMG	94.1	1036	No	No
HIP17405	55.93921	16.66598	156.198 ± 0.146	−310.030 ± 0.092	58.125 ± 0.363	⋯	ABDMG	98.4	1237	No	No
HIP17414	55.9697	16.67071	157.960 ± 0.181	−316.306 ± 0.112	58.046 ± 0.235	⋯	ABDMG	99.5	1237	No	No
HIP41181	126.05475	44.94519	−60.136 ± 0.393	−176.593 ± 0.270	27.097 ± 0.245	⋯	ABDMG	96.7	1456	No	No
HIP41184	126.06486	44.94897	−63.222 ± 0.103	−177.913 ± 0.064	27.102 ± 0.244	⋯	ABDMG	97.1	1456	No	No
HIP29964	94.61743	−72.04454	−7.670 ± 0.122	74.367 ± 0.137	25.612 ± 0.220	⋯	ABDMG(56);BPMG(44)	99.6	1806	BF	BPMG
TYC9162-379-1	79.22423	−68.35218	14.406 ± 1.465	58.566 ± 1.503	22.114 ± 0.455	⋯	ABDMG(75);BPMG(25)	97.1	1806	No	No
HIP14809	47.80793	22.41534	55.656 ± 0.110	−125.193 ± 0.090	19.711 ± 0.240	⋯	ABDMG	93.3	2048	BF	ABDMG
TYC1807-46-1	56.49168	27.55932	43.262 ± 1.190	−118.850 ± 0.468	18.245 ± 0.275	⋯	ABDMG	96.6	2048	No	No
HIP2981	9.48814	47.40737	110.257 ± 0.039	−82.865 ± 0.028	22.101 ± 0.311	⋯	ABDMG	88.3	2201	No	No
HIP3589	11.46274	54.97752	96.401 ± 0.030	−73.969 ± 0.042	19.878 ± 0.340	⋯	ABDMG	88.1	2201	BF	ABDMG
HIP118008	359.04558	−39.05311	206.231 ± 0.056	−185.819 ± 0.064	45.471 ± 0.228	⋯	ABDMG	99.8	2240	BF	ABDMG
HIP79578	243.54936	−31.66473	−75.560 ± 0.035	−256.211 ± 0.027	41.194 ± 0.476	⋯	ABDMG	98.8	2371	No	No
TYC4718-894-1	58.8352	−1.7296	42.085 ± 0.903	−91.433 ± 0.588	18.102 ± 0.250	⋯	ABDMG	97.6	2727	No	No
HIP19183	61.67321	1.68352	36.571 ± 0.063	−94.590 ± 0.037	17.547 ± 0.336	⋯	ABDMG	95.9	2727	BF	ABDMG
HIP31878	99.9582	−61.47789	−26.981 ± 0.104	74.960 ± 0.093	45.328 ± 0.236	⋯	ABDMG(75);BPMG(25)	99.8	2841	BF	ABDMG
HIP30314	95.62882	−60.21838	−11.418 ± 0.027	64.559 ± 0.028	41.973 ± 0.276	⋯	ABDMG(83);BPMG(17)	99.8	2841	BF	ABDMG
TYC5899-26-1	73.10226	−16.82363	123.265 ± 1.133	−212.593 ± 1.008	63.400 ± 0.366	⋯	ABDMG	99.6	2849	BF	ABDMG
HIP17695	56.84801	−1.97335	180.433 ± 0.170	−274.096 ± 0.127	59.266 ± 0.332	⋯	ABDMG	99.7	2849	BF	ABDMG
HIP19422	62.39687	69.54015	73.004 ± 0.037	−298.653 ± 0.055	53.358 ± 0.242	⋯	ABDMG	93.3	3017	No	No
HIP40910	125.23018	14.07024	−83.698 ± 0.137	−261.809 ± 0.080	44.351 ± 0.274	⋯	ABDMG	98.5	3493	No	No
HIP44295	135.32228	15.26443	−125.739 ± 0.122	−320.354 ± 0.082	54.658 ± 0.306	⋯	ABDMG	94.7	3493	No	No

Note. This subtable is a preview of the entire sample, which will be available as a machine-readable table. Above we show the Tycho or *Hipparcos* name along with corresponding position, proper motion, parallax, and radial velocity (where available). Columns (9) and (10) show the detailed results from BANYAN Σ of probability of membership in a nearby association (10) and the best group fit. Column (12) describes whether an object was used as a bonafide member (BF) in BANYAN Σ or whether it was a candidate member (CM), high-likelihood member (HM), ambiguous member (AM), rejected member (RM), or not investigated (NO). Column (13) reflects the corresponding group of investigation to Column (12). The Oh17 Group number is listed in Column (11). An object marked as (NO) may be a newly discovered candidate of a known group. However, we note that we did not perform a detailed literature search as to whether some of these sources were investigated by others; therefore, further vetting is required for each source.

(This table is available in its entirety in machine-readable form.)

Table 5
BANYAN Σ Summary of Oh17

BANYAN Name (1)	Total (2)	# BF (3)	# CM (4)	# HM (5)	# LM (6)	# RM (7)	# AM (8)	# NO (NEW?) (9)
118TAU	…	…	…	…	…	…	…	…
ABDMG	24	8	1	…	…	…	…	15
BPMG	6	3	…	…	…	…	…	3
CAR	0	…	…	…	…	…	…	…
CARN	9	5	…	…	…	…	…	4
CBER	45	33	2	…	…	…	…	10
COL	18	4	…	…	…	…	…	14
CRA	1	…	…	1	…	…	…	…
EPSC	10	5	2	1	…	…	1	1
ETAC	2	1	…	1	…	…	…	…
HYA	110	88	14	…	…	…	…	8
IC2391	28	18	…	8	…	…	…	2
IC2602	31	11	1	…	11	…	1	7
LCC	156	37	9	41	…	…	1	68
OCT	34	…	…	…	…	…	…	34
PL8	22	…	…	5	…	…	…	17
PLE	136	117	6	…	…	1	…	12
ROPH	…	…	…	…	…	…	…	…
TAU	33	9	…	2	…	…	…	22
THA	29	24	…	…	…	…	…	5
THOR	5	2	2	…	…	…	…	1
TWA	3	…	…	…	…	…	…	3
UCL	194	27	8	41	…	…	2	116
UCRA	2	…	…	…	…	…	…	2
UMA	1	…	1	…	…	…	…	…
USCO	107	23	4	24	…	…	…	56
XFOR	9	3	…	6	…	…	…	…

Note. The number of Oh17 objects for each BANYAN selected group that are either bonafide members (BF), candidate members (CM), high likely members (HM), low likely members (LM), ambiguous members (AM), rejected members (RM), not in BANYAN Σ (NO). The full names of BANYAN Σ groups are 118 Tau (118TAU), AB Doradus (ABDMG), β Pictoris (BPMG), Carina (CAR), Carina-Near (CARN), Coma Berenices (CBER), Columba (COL), Corona Australis (CRA), ϵ Chamaeleontis (EPSC), η Chamaeleontis (ETAC), the Hyades cluster (HYA), Lower Centaurus Crux (LCC), Octans (OCT), Platais 8 (PL8), the Pleiades cluster (PLE), ρ Ophiucus (ROPH), the Tucana-Horologium association (THA), 32 Orionis (THOR), TW Hya (TWA), Upper Centaurus Lupus (UCL), Upper CrA (UCRA), the core of the Ursa Major cluster (UMA), Upper Scorpius (USCO), Taurus (TAU), and χ For (XFOR).

Oh et al. (2017) uncovered parts of many known moving groups, open clusters, associations and star-forming regions.

The 10,606 unique stars are organized into 4555 groups. Those are further broken down into 27 groups that have $\geqslant$10 connected components—objects who passed the Oh17 kinematic association criterion—35 groups that have between 5 and 10 connected components, 39 groups that have four connected components, 218 that have three connected components, and 4,236 that have two connected components.

As noted in Oh et al. (2017), radial velocities are required for each star to further verify that comovers are not simply chance alignments, a prospect that becomes far more likely because the pairs have separations >1 pc (see Price-Whelan et al. 2017).

3. Data on the Sample

In order to examine the groups as a whole in the Oh17 sample, we supplemented the *Gaia* data for each unique star with catalog photometry and spectral information. Using the Tool for OPerations on Catalogs And Tables (TOPCAT; Taylor 2005), we cross-matched with the Two micron All Sky catalog (2MASS; Skrutskie et al. 2006), the *Wide Field Infrared Survey Explorer Mission* (*WISE*; Wright et al. 2010), the *Galaxy Evolution Explorer* (*GALEX*; Martin et al. 2005), and the *Rontgen Satellite* (*ROSAT*; Voges et al. 2000, 1999)—both bright and faint source catalogs. For 2MASS and WISE, we used a 1$''$ radius to match to ALLWISE, which automatically had a cross-match with 2MASS at the 3$''$ level. For *GALEX*, we used 5$''$ and *ROSAT* we used 30$''$ given their larger pixel sizes and greater positional uncertainties. We also used TOPCAT to cross-match all 10,606 unique stars with the Catalog of Stellar Spectral Classifications compiled by Skiff (2014). We list the recovered 2MASS JHK_s, WISE $W1W2W3W4$, *GALEX* FUV and NUV photometry, *ROSAT* X-ray flux values as well as Skiff (2014) spectral type in Tables 1–3. We used the photometry in combination with the *Gaia* parallaxes in order to investigate color–magnitude diagrams and search for age-informative diagnostics in Section 5 below.

4. The Oh17 Sample Reorganized

As the Oh17 sample is organized into groups with only a few known collections of stars explicitly described, in this section, we reorganize the comovers into their known associations, label them as new candidate members of groups, or recommend a collection of stars as an entirely new pair or comoving association. A detailed literature search of new comoving pairs would normally be warranted to execute this task, however, it is time consuming to sift through the numerous references to Tycho and *Hipparcos* stars (although, see Gagné & Faherty 2018 for an analysis of new members across all of TGAS). To expedite the reorganization into known associations, we

Table 6
BANYAN Groups Matched to Oh17

BANYAN Name (1)	# Oh17 Groups (2)	Oh17 Group Number (3)	# in BANYAN (4)	# in Oh17 Groups (5)	Age (Myr) (6)	Age References (7)
118TAU	…	…	…	…	∼10	14
ABDMG	14	1036, 1237, 1456, 1806, 2048, 2201, 2240, 2371, 2727, 2841, 2849, 3017, 3493, 3709	24	28	149^{+51}_{-19}	1
BPMG	3	241, 2230, 3062	6	7	24 ± 3	1
CAR	…	…	…	…	45^{+11}_{-7}	1
CARN	5	215, 272, 2347, 2785, 3746	9	12	∼200	2
CBER	1	7	45	47	562^{+98}_{-84}	3
COL	7	355, 93, 241, 690, 1460, 2495, 4103	18	23	42^{+6}_{-4}	1
CRA	1	3261	1	2	4-5	16
EPSC	1	3	10	114	$3.7^{+4.6}_{-1.4}$	4
ETAC	1	2071	2	2	11 ± 3	1
HYA	3	2, 261, 3208	110	123	750 ± 100	5
IC2391	2	9, 2520	28	38	50 ± 5	18
IC2602	1	5	31	59	46^{+6}_{-5}	6
LCC	21	3, 13, 40, 45, 48, 75, 77, 100, 183, 239, 255, 266, 937, 1340, 2035, 2091, 2162, 2206, 2283, 2288, 4032	156	197	15 ± 3	7
OCT	14	31,37, 143, 670, 2351, 2974, 3508, 3521, 3562, 3730, 3994, 3995, 4187, 4289, 4340	34	38	35 ± 5	8
PL8	4	12, 269, 574, 4289	22	30	∼60	9
PLE	1	0	136	151	112 ± 5	10
ROPH	…	…	…	…	<2	13
TAU	9	28, 29, 286, 300, 1348, 3774, 3824, 3856, 3870	33	34	1-2	15
THA	6	15, 221, 303, 673, 951, 1022	29	35	45 ± 4	1
THOR	1	44	5	6	22^{+4}_{-3}	1
TWA	2	172, 3001	3	5	10 ± 3	1
UCL	38	8, 11, 13, 18, 24, 25, 33, 40, 45, 46 54, 92, 94, 99,114 239, 299, 304, 308, 408, 668, 672, 1443, 2239, 2668, 2828, 3019, 3155, 3238, 3245, 3362, 3908, 4027, 4132, 4218, 4300, 4404, 4490	194	215	16 ± 2	7
UCRA	2	1308, 3261	2	4	10	17
UMA	1	1058	1	2	414 ± 23	11
USCO	11	4, 25, 27, 69, 113, 114, 131, 155, 447, 831, 1242	107	115	10 ± 3	7

Table 6
(Continued)

BANYAN Name (1)	# Oh17 Groups (2)	Oh17 Group Number (3)	# in BANYAN (4)	# in Oh17 Groups (5)	Age (Myr) (6)	Age References (7)
XFOR	1	19	9	13	∼500	12
		NON-BANYAN				
Alpha Perseus	⋯	1	⋯	125		
RSG 2[a]	⋯	16	⋯	18		
Blanco1	⋯	17	⋯	16		
Praesepe	⋯	6, 4141	⋯	60		
NGC2451A	⋯	21, 233, 236	⋯	18		
Platais 9	⋯	22	⋯	18		
NGC2516	⋯	3967	⋯	2		
NGC3532	⋯	3116	⋯	2		
NGC6475	⋯	57, 2870, 2891, 2983	⋯	11		
NGC6633	⋯	1335	⋯	2		
NGC7092	⋯	3101	⋯	2		

Notes. All 21 of the BANYAN Σ tested groups compared to the Oh17 catalog group numbers. Non-BANYAN tested groups are also listed with corresponding Oh17 group numbers. The full names of BANYAN Σ groups are 118 Tau (118TAU), AB Doradus (ABDMG), β Pictoris (BPMG), Carina (CAR), Carina-Near (CARN), Coma Berenices (CBER), Columba (COL), Corona Australis (CRA), ϵ Chamaeleontis (EPSC), η Chamaeleontis (ETAC), the Hyades cluster (HYA), Lower Centaurus Crux (LCC), Octans (OCT), Platais 8 (PL8), the Pleiades cluster (PLE), ρ Ophiucus (ROPH), the Tucana-Horologium association (THA), 32 Orionis (THOR), TW Hya (TWA), Upper Centaurus Lupus (UCL), Upper CrA (UCRA), the core of the Ursa Major cluster (UMA), Upper Scorpius (USCO), Taurus (TAU), and χ For (XFOR).
[a] A new open cluster discovered recently by Röser et al. (2016).

References: (1) Bell et al. (2015); (2) Zuckerman et al. (2006); (3) Silaj & Landstreet (2014); (4) Murphy et al. (2013); (5) Brandt & Huang (2015b); (6) Dobbie et al. (2010); (7) Pecaut & Mamajek (2016); (8)Murphy & Lawson (2015); (9) Platais et al. (1998); (10) Dahm (2015); (11) Jones et al. (2015); (12) Pöhnl & Paunzen (2010); (13) Wilking et al. (2008); (14) Mamajek (2016); (15) Kenyon & Hartmann (1995); (16) Gennaro et al. (2012); (17) Gagné et al. (2018a); (18) Barrado y Navascués et al. (2004).

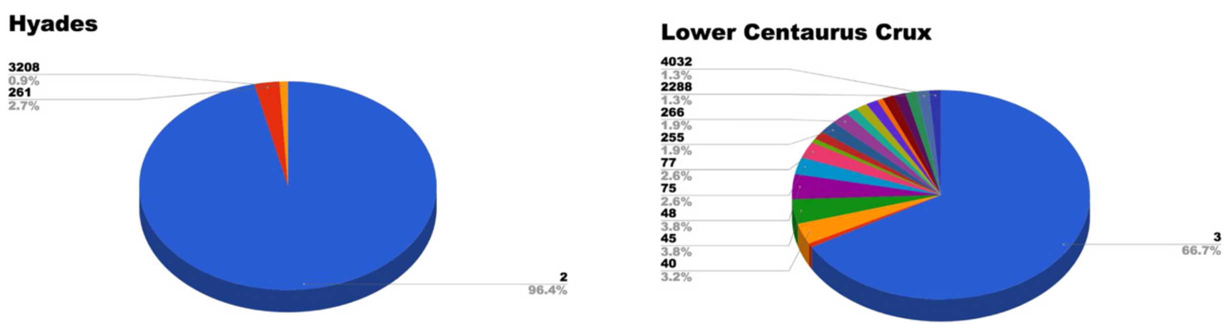

Figure 1. Pie chart distribution of Oh17 designated groups with >80% membership in a BANYAN Σ tested association. The percentages are based on the total number of objects that BANYAN found to be members and the contribution by an individually marked Oh17 group (labeled above the percentage). On the left, we show the distribution of BANYAN Σ predicted Hyades members and on the right are Lower Centaurus Crux members. Each Oh17 group has been color coded in the pie chart. We label the group number with percentage of the total at each pie slice.

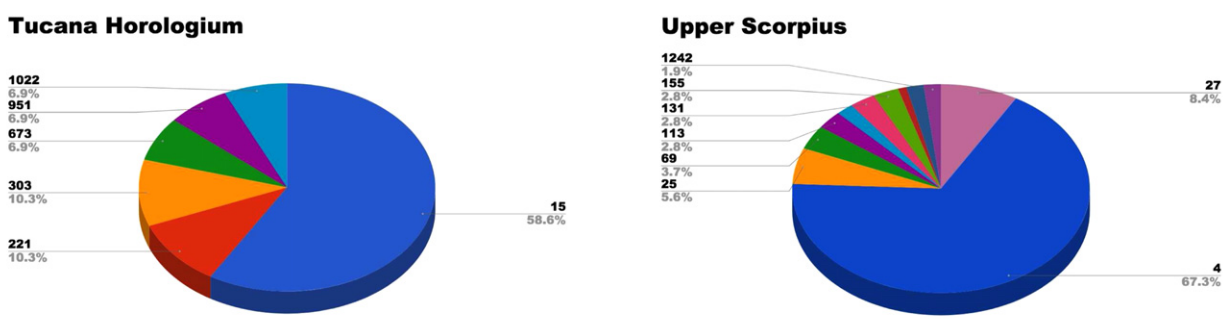

Figure 2. See the caption of Figure 1. On the left, we show the distribution of BANYAN Σ predicted Tucana Horologium members and on the right are Upper Scorpius members.

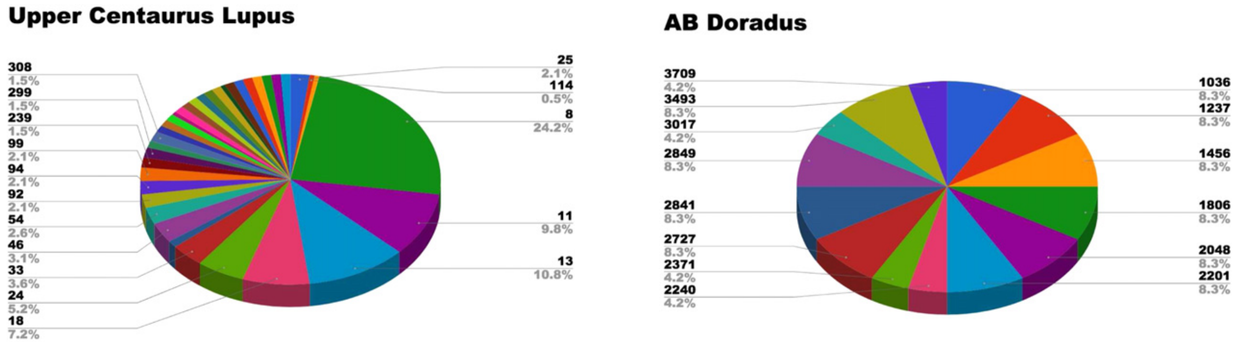

Figure 3. See the caption of Figure 1. On the left, we show the distribution of BANYAN Σ predicted Upper Centaurus Lupus members and on right are AB Doradus members.

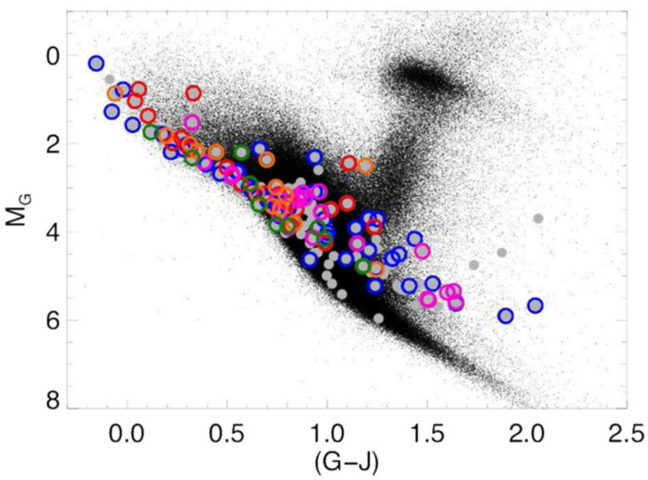

Figure 4. $(G-J)$ vs. M_G color–magnitude diagram for TGAS (black) and all BANYAN $\Sigma > 80\%$ membership probability of the Upper Centaurus Lupus association (UCL). We highlight in different colored circles the five largest Oh17 groups that were found to be comoving members of UCL.

utilized a kinematic tool called BANYAN Σ (Gagné et al. 2018a). This tool uses a compiled list of bonafide members (see Gagné et al. 2018a for details on the bonafide definition) of 27 different associations within 150 pc of the Sun to determine the probability of a given star on the sky also being associated.

4.1. Oh17 sample in BANYAN

To begin sorting which group corresponded to which known association of stars, we first applied the BANYAN Σ kinematic code (Gagné et al. 2018a) to each of the 10,606 unique stars to ascertain the Bayesian probability that it belonged (new or known) to one of 27 comoving collections. We chose a moderate membership probability threshold of >80% Bayesian likelihood for membership in a known group. This number is arbitrary and moderately conservative (e.g., Gagné & Faherty 2018 used >90% for their threshold) but given that these sources already have at least one connected component, we think it is justified. Table 4 shows that 1015 unique stars passed the probability criterion for 1 of the 27 collections tested by BANYAN. Table 4 gives the probability that an object was a member of a BANYAN tested association (column 10) but it also gives a breakdown of likelihood if it had a chance of being in more than one group (column 9).

Table 7
Oh17 Group with Conflicting BANYAN Prediction

Oh17 Group # (1)	BANYAN Group (2)
3	EPSC, LCC
13	UCL, LCC
25	UCL, USCO
40	LCC, UCL
45	UCL, LCC
114	USCO, UCL
239	LCC, UCL
241	BPMG, COL
3261	CRA, UCRA

Note. A list of the Oh17 groups that had members with >80% probability in more than 1 BANYAN Σ tested group.

A few things of note came from the BANYAN results. Given the 80% group membership probability that we employed to investigate the Oh17 comoving stars, there were times when one object in a comoving pair was found to be a part of a known group, while its designated partner was not. For instance, in the AB Doradus moving group, there were 24 individual stars identified by BANYAN to have a >80% probability of membership. However, there were four double-connected components in Oh17 where only one of the two stars was recovered as a AB Doradus member (e.g., Oh17 group 2240, which contains a bonafide member). This occurred across all of the 27 BANYAN groups. Given that the Oh et al. (2017) method requires matching kinematics for the pairs to emerge, we postulate that the majority of these broken up groups is due to the second component having a probability that simply did not exceed our 80% threshold. Further investigation may prove that its connected partner(s) is also a candidate member, but with a lower likelihood. All known information and BANYAN results are reported in Table 4.

4.2. Known Associations from BANYAN

Using the >80% probability threshold, members of each of the 27 BANYAN Σ tested groups were identified. It is important to note that the Oh et al. (2017) method was not designed to identify these large kinematic associations; therefore, it is not expected that it would or should recover all known members possible from Tycho and *Hipparcos* in a given association (see Gagné et al. 2018b). As such, we emphasize that the Oh17 sample is not a complete look at

Table 8
Potentially New Associations from Oh17 with >10 Connected Components

Name	R.A.	Decl.	SpT	μ_α (mas $^{-1}$)	μ_δ (mas $^{-1}$)	π (mas)	Group
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HIP69721	214.07256	58.38940	F5	−16.254 ± 0.039	−2.903 ± 0.049	9.341 ± 0.293	10
HIP67005	205.97812	52.06439	A1V	−18.270 ± 0.018	−5.605 ± 0.021	10.737 ± 0.325	10
TYC3851-600-1	207.11420	54.04270	⋯	−18.288 ± 0.297	−3.934 ± 0.783	10.709 ± 0.255	10
HIP67231	206.64844	54.43266	A2P	−18.533 ± 0.018	−4.750 ± 0.021	10.333 ± 0.503	10
TYC3851-336-1	205.40212	53.33751	G0	−18.006 ± 0.617	−3.350 ± 0.743	10.040 ± 0.261	10
TYC3851-369-1	205.78236	54.02590	G5	−19.004 ± 0.298	−2.867 ± 0.663	10.431 ± 0.297	10
HIP66198	203.53030	55.34841	⋯	−19.079 ± 0.022	−6.070 ± 0.023	10.704 ± 0.570	10
TYC3850-257-1	201.21590	54.89743	A5	−19.011 ± 0.347	−6.271 ± 0.396	11.125 ± 0.264	10
HIP63702	195.81947	57.31521	F8	−17.103 ± 0.063	−8.196 ± 0.070	10.246 ± 0.261	10
TYC3480-1209-1	223.27004	51.26115	K2	−14.193 ± 0.392	−0.685 ± 0.682	9.772 ± 0.238	10
TYC3868-177-1	230.81618	54.84823	⋯	−13.792 ± 0.398	−1.234 ± 0.845	8.986 ± 0.262	10
HIP74458	228.24117	56.04643	A2	−13.157 ± 0.041	−1.189 ± 0.039	8.672 ± 0.300	10
TYC3861-1374-1	222.52355	53.63483	⋯	−14.564 ± 0.914	−1.915 ± 0.748	9.633 ± 0.295	10
TYC3860-1483-1	219.85980	54.77406	⋯	−17.561 ± 0.458	−2.798 ± 0.653	10.964 ± 0.261	10
HIP72389	222.01173	56.15920	G5	−15.865 ± 0.117	−1.522 ± 0.123	10.266 ± 0.221	10
HIP69917	214.62966	52.03331	A2	−17.194 ± 0.026	−3.122 ± 0.030	10.059 ± 0.271	10
HIP69650	213.82070	52.53591	A4V	−17.603 ± 0.022	−3.474 ± 0.027	10.402 ± 0.280	10
HIP69958	214.73284	54.86376	A5Vn	−16.565 ± 0.029	−2.063 ± 0.029	9.790 ± 0.681	10
TYC3865-934-1	216.29629	57.63321	G0	−15.381 ± 0.367	−2.485 ± 0.645	9.571 ± 0.284	10
HIP73730	226.07328	59.53505	A2	−13.661 ± 0.027	−0.164 ± 0.029	9.000 ± 0.275	10
TYC3875-762-1	231.92341	59.98704	⋯	−13.297 ± 0.289	0.094 ± 1.020	8.928 ± 0.281	10
TYC3867-281-1	226.10718	59.88078	K2	−13.399 ± 0.353	−0.068 ± 1.138	9.351 ± 0.280	10
HIP71911	220.63149	60.23096	F0	−16.235 ± 0.065	−3.840 ± 0.066	9.428 ± 0.219	10
TYC3867-1373-1	222.87595	59.53208	⋯	−15.362 ± 0.456	−1.742 ± 1.371	9.638 ± 0.392	10
TYC4173-609-1	219.82002	61.93126	⋯	−17.035 ± 0.363	−3.995 ± 0.976	9.892 ± 0.300	10
HIP69275	212.72088	62.52220	F2IV	−17.166 ± 0.043	−3.034 ± 0.050	9.678 ± 0.247	10
TYC4174-1117-1	209.67123	63.68876	⋯	−18.907 ± 0.583	−4.208 ± 0.691	10.613 ± 0.260	10
TYC3471-233-1	211.95507	51.95266	⋯	−16.804 ± 0.351	−4.588 ± 0.894	9.982 ± 0.242	10
HIP68637	210.74889	50.97178	A0IV	−16.444 ± 0.018	−6.210 ± 0.019	9.936 ± 0.418	10
TYC9280-112-1	258.43252	−69.98264	⋯	−11.735 ± 0.607	−12.739 ± 0.774	4.244 ± 0.253	14
TYC9279-1700-1	256.44526	−70.39820	A(?)	−13.393 ± 0.421	−13.273 ± 0.472	4.424 ± 0.241	14
TYC9279-2048-1	254.64074	−70.24192	⋯	−13.924 ± 0.544	−12.111 ± 0.681	4.330 ± 0.219	14
TYC9279-1772-1	254.96898	−70.17474	⋯	−13.458 ± 0.493	−12.506 ± 0.712	4.361 ± 0.264	14
TYC9275-1592-1	252.40693	−69.30057	⋯	−14.436 ± 0.554	−13.326 ± 0.713	4.734 ± 0.252	14
TYC9275-963-1	255.52187	−68.19909	⋯	−13.093 ± 0.456	−12.835 ± 0.652	4.478 ± 0.222	14
TYC9276-2997-1	258.71396	−68.85196	⋯	−11.928 ± 0.512	−13.501 ± 0.699	4.222 ± 0.231	14
TYC9275-2648-1	255.75727	−68.62989	A1V	−13.721 ± 0.306	−13.050 ± 0.296	4.639 ± 0.406	14
TYC9275-2499-1	255.66161	−68.61236	⋯	−13.545 ± 0.483	−13.917 ± 0.716	4.516 ± 0.247	14
TYC9275-3434-1	257.82869	−68.11085	⋯	−12.428 ± 0.365	−12.500 ± 0.628	4.284 ± 0.269	14
TYC9275-1819-1	256.02271	−68.19380	⋯	−12.999 ± 0.438	−12.991 ± 0.577	4.348 ± 0.246	14
TYC9275-1067-1	255.89374	−67.88703	A2Vs	−12.990 ± 0.369	−12.302 ± 0.419	4.280 ± 0.275	14
TYC9275-2142-1	254.16395	−68.35217	A6III	−13.716 ± 0.446	−12.913 ± 0.547	4.601 ± 0.275	14
TYC9275-251-1	252.96875	−68.07482	⋯	−13.832 ± 0.544	−11.963 ± 0.576	4.422 ± 0.317	14
TYC9050-754-1	252.84677	−67.47804	⋯	−14.366 ± 0.434	−13.203 ± 0.572	4.583 ± 0.244	14
TYC9275-1107-1	254.72914	−67.78803	A5IV	−14.559 ± 0.445	−13.242 ± 0.475	4.544 ± 0.299	14
TYC9064-2249-1	257.50549	−66.88909	⋯	−13.776 ± 0.452	−14.554 ± 0.734	4.672 ± 0.246	14
TYC9051-124-1	254.90482	−66.98483	⋯	−13.290 ± 0.440	−12.357 ± 0.637	4.457 ± 0.276	14
HIP82908	254.13678	−66.10902	A0V	−14.133 ± 0.039	−12.773 ± 0.037	4.436 ± 0.321	14
TYC9050-901-1	250.97105	−67.24941	⋯	−15.309 ± 0.528	−13.511 ± 0.715	4.755 ± 0.265	14
TYC8950-174-1	148.39804	−64.19227	A(?)	−28.902 ± 0.707	23.115 ± 0.660	4.874 ± 0.323	23
HIP48707	149.02216	−63.11015	A4V	−29.082 ± 0.071	23.529 ± 0.067	4.717 ± 0.269	23
TYC8951-88-1	151.54021	−63.92761	A2V	−29.790 ± 0.707	22.781 ± 0.628	5.008 ± 0.242	23
HIP48873	149.52952	−62.58526	G5/6III	−29.149 ± 0.030	23.367 ± 0.028	4.735 ± 0.254	23
TYC8946-285-1	148.20684	−62.10954	⋯	−29.946 ± 0.915	23.556 ± 0.656	4.446 ± 0.267	23
TYC8942-2165-1	148.16318	−61.72158	⋯	−29.677 ± 0.903	23.039 ± 0.632	4.406 ± 0.267	23
HIP48281	147.65756	−60.52759	A1IV	−28.084 ± 0.027	23.504 ± 0.028	4.580 ± 0.336	23
TYC8941-397-1	145.63238	−60.09132	A5IV	−26.126 ± 0.730	23.833 ± 0.752	4.611 ± 0.326	23
TYC8943-2975-1	150.07020	−61.51121	⋯	−31.134 ± 0.803	23.904 ± 0.569	4.696 ± 0.242	23
TYC8942-2267-1	146.93234	−60.93701	⋯	−28.471 ± 1.132	23.109 ± 0.985	4.311 ± 0.350	23
TYC3713-616-1	44.21811	58.58569	G0	32.929 ± 0.829	−29.927 ± 0.451	8.431 ± 0.239	26

Table 8
(Continued)

Name	R.A.	Decl.	SpT	μ_α (mas $^{-1}$)	μ_δ (mas $^{-1}$)	π (mas)	Group
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TYC3715-742-1	50.82901	58.72919	A5	31.259 ± 0.507	−34.520 ± 0.375	8.369 ± 0.247	26
TYC4062-755-1	52.27789	60.56034	G5	32.722 ± 0.834	−38.415 ± 0.547	8.684 ± 0.257	26
TYC4048-1560-1	46.98214	60.52351	…	29.288 ± 1.353	−29.686 ± 0.622	7.930 ± 0.322	26
TYC4049-648-1	47.75587	60.95448	A3II	29.963 ± 0.561	−30.319 ± 0.393	7.470 ± 0.231	26
TYC4053-1110-1	51.31316	62.12718	…	32.027 ± 1.392	−36.279 ± 0.756	8.752 ± 0.278	26
HIP12355	39.76509	62.57544	A0	33.219 ± 0.034	−25.385 ± 0.039	7.596 ± 0.264	26
HIP12346	39.74336	62.59140	B9	33.483 ± 0.021	−25.348 ± 0.024	7.808 ± 0.434	26
TYC4056-654-1	46.26338	65.18254	F8	33.095 ± 0.390	−29.208 ± 0.386	7.969 ± 0.318	26
TYC3715-701-1	51.58515	58.88690	F5	35.325 ± 0.750	−37.785 ± 0.514	9.274 ± 0.243	26

Note. Collections of stars in Groups 10, 14, 23, and 26 from the Oh17 sample that appear to be newly discovered.

known groups or even one where a significant portion of members should be identified.

That stated, for our own purposes, we cross-matched all of the individual stars with the bonafide (BM), candidate (CM), high-likelihood (HM), low-likelihood (LM), ambiguous (AM), and rejected member (RM) lists used in Gagné et al. (2018a) to create BANYAN Σ. Column (12) and column (13) of Table 4 reflect on whether an object might be a new candidate that requires further vetting (NO) or whether it falls in one of the above listed BANYAN categories (BM, CM, LM, AM, or RM). Table 5 summarizes each of the 27 BANYAN tested groups. We note that the NO objects may still be known literature sources, however, they are not in BANYAN Σ and we only performed a cursory check in the literature for the most prominent associations. In the case of the Hyades, the Pleiades, and Coma Berenices, we verified that all of the NO sources were discussed as members in the literature therefore there are no new additions in the Oh17 catalog. The remaining groups with NO objects listed, may have new members uncovered. Specifically, given that there is a significant number of Oh17 stars that are connected components to known or candidate members of associations, we suggest there is a significant number of new additions to moving groups uncovered. Detailed vetting and literature searching is required to confirm new objects.

Organizing the Oh17 groups/pairs by BANYAN results as laid out in Table 6, we find that Upper Centaurus Lupus (194 > 80% probability members) and Lower Centaurus Crux (156 > 80% probability members) were found in greatest number. Conversely, the groups 118TAU, ρ Ophiucus, and Carina were not recovered at all.

Members of Pleiades (Oh17 group 0), Coma Berenices (Oh17 group 7), IC 2602 (Oh17 group 5), and Alessi 13 (Oh17 group 19) were recovered from BANYAN Σ as all belonging to the same Oh17 defined group. However—with the exception of Corona Australis, ϵ Chamaeleontis, η Chamaeleontis, and Ursa Major where only one pair (or one object in a pair) was recovered—the remaining 15 BANYAN Σ groups were recovered across more than one Oh17 defined group (see Figures 1–3 for pie charts illustrating the distributions). For instance, BANYAN Σ found 107 > 80% membership probability Upper Scorpius stars. However, as illustrated in Figure 2, those are spread across 11 different Oh17 groups. Among those, Oh17 group 4 (with 72 members), was the largest collection of Upper Scorpius objects, all of which came out as >80% membership BANYAN probability in the association. The 10 other Oh17 groups with the 35 remaining >80% membership probability Upper Scorpius stars ranged in size from 2 to 10.

We investigated whether this substructure of Oh17 groups for the same BANYAN predicted group was significant but found no obvious evidence for a correlation with the members and their Oh17 group assignment. For example, in Figure 4, we look at the five largest Oh17 groups that came out as Upper Centaurus Lupus in BANYAN on a $(G - J)$ versus M_G color–magnitude diagram. While we see nothing striking, Röser et al. (2018) report that using TGAS astrometry, spatial positions, and some follow-up radial velocities, they find that Group 11 is part of a compact new moving group around V1062 Sco. Further investigation is required for each of the individual groups to see if they end up mapping fine detailed kinematic structures or substructures within a larger association.

Groups that were particularly close to the Sun (distance $\ll$100 pc) were almost entirely broken into pairs or triples by Oh et al. (2017). For instance, as illustrated in Figure 3, the AB Doradus moving group whose members span from 7 to 77 pc from the Sun and are scattered in R.A. and decl. all over the sky, spanned 14 different Oh17 groups. The Oh et al. (2017) method probably breaks down for nearby groups given that the closer an association is to the Sun, the more important understanding the full kinematics becomes to deciphering membership. With the Oh et al. (2017) method, radial velocity measurements are not employed, making it difficult to differentiate the full kinematic signature of solar neighborhood groups.

We also found that several of the Oh17 groups with >10 sources had a mixture of objects with different BANYAN predicted associations. Table 7 lists each of the Oh17 groups that had a component in more than one of the BANYAN Σ tested groups. For instance, Oh17 group 25 has six BANYAN predicted members of Upper Scorpius and four BANYAN predicted members of Upper Centaurus Lupus. Group 13 has one BANYAN predicted member of Lower Centaurus Crux and 21 predicted members of Upper Centaurus Lupus. These associations are known to have cross-contaminating kinematics as they occupy a similar part of XYZUVW space, so it is not surprising that the Oh17 method found them together. Moreover, lacking a radial velocity means there is a crucial kinematic component missing for associations that are already very similar.

Table 9
Potentially New Associations from Oh17 with Five to Nine Connected Components

Name (1)	R.A. (2)	Decl. (3)	SpT (4)	μ_α mas $^{-1}$ (5)	μ_δ mas $^{-1}$ (6)	π mas (7)	Group (8)
TYC8950-1447-1	147.07979	−64.05587	⋯	−43.466 ± 1.072	46.020 ± 0.687	12.982 ± 0.268	30
HIP45594	139.39198	−63.38719	F3V	−28.931 ± 0.050	42.406 ± 0.050	11.025 ± 0.246	30
TYC9210-1730-1	153.12405	−67.87577	⋯	−47.205 ± 0.715	42.869 ± 0.510	12.245 ± 0.232	30
TYC9210-1818-1	152.09121	−67.94434	⋯	−39.815 ± 1.079	38.142 ± 0.717	11.325 ± 0.315	30
HIP47335	144.68804	−66.85889	A9IV/V	−36.597 ± 0.052	45.317 ± 0.054	11.671 ± 0.232	30
TYC8953-1289-1	144.79319	−66.77079	⋯	−37.709 ± 3.199	45.094 ± 2.661	11.653 ± 0.376	30
HIP46460	142.12690	−66.70166	A0V	−35.443 ± 0.025	49.410 ± 0.026	12.977 ± 0.461	30
HIP47017	143.73490	−64.99927	F5V	−34.670 ± 0.068	44.232 ± 0.061	11.620 ± 0.234	30
TYC7700-1309-1	144.25993	−42.63547	⋯	−32.821 ± 0.973	14.060 ± 0.463	6.968 ± 0.272	34
HIP48403	148.03021	−43.79756	A9IV/V(m)	−35.664 ± 0.041	13.527 ± 0.044	7.488 ± 0.390	34
TYC7702-1556-1	148.57572	−41.70651	F8	−33.243 ± 0.925	12.140 ± 0.441	7.324 ± 0.321	34
TYC7690-1513-1	139.75253	−43.40861	F5V	−31.488 ± 0.879	16.398 ± 0.897	7.181 ± 0.312	34
HIP47161	144.15275	−42.08476	F3V	−33.935 ± 0.102	14.598 ± 0.099	6.982 ± 0.222	34
HIP48234	147.50611	−40.16895	A1/2V	−34.784 ± 0.033	12.641 ± 0.034	7.230 ± 0.274	34
TYC7700-2419-1	144.21453	−41.97493	⋯	−30.378 ± 1.091	12.498 ± 0.502	6.833 ± 0.330	34
TYC3698-2538-1	34.17816	58.21182	F2IV	36.798 ± 0.673	−27.865 ± 0.575	8.674 ± 0.274	35
HIP9690	31.16681	65.10339	A0V	43.445 ± 0.021	−26.549 ± 0.025	9.598 ± 0.506	35
TYC3697-428-1	30.91825	59.76027	F0II	41.841 ± 0.576	−28.335 ± 0.468	9.832 ± 0.271	35
TYC4036-884-1	29.99388	62.69480	⋯	45.049 ± 0.445	−27.465 ± 0.763	9.433 ± 0.300	35
HIP11156	35.87925	61.77354	F5V	39.542 ± 0.065	−29.346 ± 0.060	9.169 ± 0.270	35
TYC4046-788-1	35.85626	61.78297	⋯	40.546 ± 1.380	−29.693 ± 0.507	8.966 ± 0.240	35
TYC4037-1304-1	32.35060	63.22518	⋯	37.965 ± 0.544	−24.123 ± 0.740	8.351 ± 0.232	35
TYC3698-1416-1	34.05663	58.66893	⋯	16.484 ± 1.081	−13.733 ± 0.410	2.631 ± 0.235	36
HIP10844	34.89591	59.30818	A2V	15.517 ± 0.071	−13.776 ± 0.063	2.649 ± 0.253	36
TYC3698-475-1	35.90293	59.92108	A3V	15.083 ± 0.785	−13.633 ± 0.484	2.661 ± 0.228	36
TYC3698-985-1	34.16233	59.83703	⋯	15.798 ± 0.972	−13.631 ± 0.377	2.677 ± 0.228	36
TYC3698-495-1	33.51432	59.79895	⋯	15.683 ± 1.094	−13.389 ± 0.398	2.678 ± 0.225	36
TYC3698-3123-1	36.63970	58.36576	⋯	15.503 ± 1.030	−14.365 ± 0.453	2.673 ± 0.258	36
TYC3698-747-1	33.46726	59.75090	A0V	15.850 ± 1.151	−13.708 ± 0.437	2.628 ± 0.239	36
HIP117376	356.99239	78.37609	F8	22.344 ± 0.090	1.349 ± 0.084	6.359 ± 0.228	38
TYC4500-124-1	0.17226	79.67775	G	22.601 ± 0.637	0.630 ± 0.602	6.372 ± 0.278	38
TYC4500-310-1	9.91810	79.09186	⋯	23.259 ± 0.888	−3.678 ± 0.837	6.681 ± 0.259	38
TYC4500-1478-1	9.52596	79.05572	⋯	22.385 ± 0.644	−2.306 ± 0.722	6.549 ± 0.249	38
TYC4501-1813-1	11.34654	79.73042	F5	23.907 ± 1.174	−3.876 ± 0.654	6.687 ± 0.250	38
TYC4500-616-1	4.36837	79.79943	⋯	23.831 ± 1.096	−1.806 ± 1.129	6.291 ± 0.282	38
HIP115764	351.80796	79.54195	A2	21.916 ± 0.038	4.080 ± 0.040	6.364 ± 0.700	38
HIP23819	76.79954	−3.49642	A2/3V	11.312 ± 0.067	−13.707 ± 0.054	5.741 ± 0.281	39
TYC4745-475-1	73.30027	−3.81951	⋯	13.013 ± 0.818	−14.544 ± 0.693	6.125 ± 0.237	39
HIP23386	75.41076	−2.72076	A1/2V	11.985 ± 0.065	−14.462 ± 0.050	5.481 ± 0.330	39
TYC4741-307-1	74.07619	−1.89251	⋯	11.062 ± 1.004	−14.083 ± 0.754	5.690 ± 0.244	39
HIP22716	73.27011	−1.27584	A7/F0	12.649 ± 0.061	−15.773 ± 0.041	5.867 ± 0.344	39
HIP22689	73.19139	0.68718	F8	11.499 ± 0.214	−15.130 ± 0.124	5.707 ± 0.237	39
HIP23661	76.27642	−3.67021	A2V	11.557 ± 0.056	−13.612 ± 0.046	6.091 ± 0.336	39
TYC9233-1754-1	170.35634	−72.84477	A2V	−25.955 ± 0.878	−1.928 ± 0.613	4.120 ± 0.267	41
HIP54740	168.12389	−71.74939	B8V	−25.582 ± 0.036	−1.247 ± 0.039	4.222 ± 0.244	41
TYC9220-3213-1	166.17019	−71.67039	⋯	−26.136 ± 0.754	−0.681 ± 0.592	4.076 ± 0.245	41
HIP54712	168.02257	−71.21747	B7Vn	−26.348 ± 0.032	−1.295 ± 0.031	4.420 ± 0.274	41
TYC9216-1951-1	167.26498	−70.49593	⋯	−26.590 ± 0.812	−1.286 ± 0.672	4.080 ± 0.266	41
TYC9220-3429-1	164.25354	−71.35402	⋯	−25.284 ± 0.472	0.389 ± 0.466	4.278 ± 0.266	41
TYC9233-453-1	170.14833	−72.02462	⋯	−24.680 ± 0.999	−1.998 ± 0.563	4.107 ± 0.367	41
TYC3709-701-1	45.22227	56.76031	⋯	28.772 ± 1.063	−27.059 ± 0.491	6.725 ± 0.257	42
TYC3700-400-1	40.67272	54.15157	⋯	27.166 ± 1.150	−21.516 ± 0.634	6.275 ± 0.279	42
TYC3709-588-1	46.63326	56.33607	⋯	28.689 ± 1.578	−26.658 ± 0.792	6.524 ± 0.345	42
HIP14047	45.22317	52.35193	B9V	27.129 ± 0.065	−24.901 ± 0.068	6.770 ± 0.437	42
TYC3309-1348-1	42.21890	52.47538	⋯	28.137 ± 0.914	−24.381 ± 0.668	6.647 ± 0.347	42
HIP13488	43.41998	53.80268	A2	28.509 ± 0.070	−26.244 ± 0.051	6.812 ± 0.250	42
TYC661-692-1	57.71066	11.00143	F8	23.839 ± 0.716	−23.964 ± 0.409	6.476 ± 0.241	43

Table 9
(Continued)

Name (1)	R.A. (2)	Decl. (3)	SpT (4)	μ_α mas $^{-1}$ (5)	μ_δ mas $^{-1}$ (6)	π mas (7)	Group (8)
HIP18033	57.81623	13.04598	B9II-III	23.194 ± 0.030	−22.986 ± 0.013	6.483 ± 0.546	43
TYC664-136-1	57.91530	14.79663	⋯	25.105 ± 0.741	−24.219 ± 0.428	6.280 ± 0.252	43
HIP18778	60.33910	9.33362	F8	25.241 ± 0.122	−26.186 ± 0.068	6.548 ± 0.256	43
TYC662-820-1	59.08010	11.41968	⋯	25.069 ± 1.335	−24.482 ± 0.556	6.660 ± 0.412	43
TYC662-217-1	59.92566	12.16893	⋯	23.671 ± 0.693	−24.894 ± 0.424	6.824 ± 0.317	43
TYC3698-121-1	33.52886	59.73304	A0V	15.448 ± 1.083	−13.620 ± 0.420	2.882 ± 0.241	47
HIP9795	31.49397	60.27831	G2II	16.715 ± 0.096	−13.524 ± 0.088	2.914 ± 0.231	47
TYC3698-1347-1	33.38928	59.42791	⋯	15.654 ± 0.960	−13.609 ± 0.345	2.873 ± 0.232	47
TYC3698-501-1	33.37689	59.45773	⋯	16.153 ± 0.827	−13.464 ± 0.589	2.954 ± 0.282	47
TYC3698-1731-1	33.82643	59.81540	⋯	15.228 ± 1.096	−13.427 ± 0.462	2.887 ± 0.223	47
TYC4033-2479-1	32.66574	60.07869	K0	15.567 ± 0.965	−13.498 ± 0.524	2.836 ± 0.238	47
HIP43909	134.17590	−63.04840	B8/9Vn	−27.470 ± 0.028	14.054 ± 0.027	4.914 ± 0.335	49
HIP43135	131.79257	−63.81253	A0V	−26.131 ± 0.054	15.481 ± 0.040	5.154 ± 0.263	49
TYC8930-1190-1	132.04977	−63.35331	⋯	−26.729 ± 0.851	15.076 ± 0.682	4.987 ± 0.248	49
TYC8930-2088-1	132.27606	−63.06794	⋯	−27.764 ± 1.167	15.406 ± 1.033	5.327 ± 0.413	49
TYC8931-646-1	135.02120	−63.28649	⋯	−26.964 ± 1.219	12.878 ± 1.097	5.076 ± 0.264	49
TYC8930-1213-1	131.06627	−62.51399	⋯	−25.408 ± 0.911	15.105 ± 0.805	5.184 ± 0.294	49
TYC5314-259-1	68.38328	−7.97834	⋯	−4.724 ± 1.069	−2.278 ± 0.815	6.333 ± 0.229	51
TYC4746-535-1	68.21826	−5.72537	F3V	−3.875 ± 0.516	−2.017 ± 0.713	6.516 ± 0.639	51
TYC4743-981-1	69.40904	−5.51202	A9V	−4.823 ± 0.500	−2.146 ± 0.455	6.487 ± 0.321	51
TYC5317-617-1	68.64190	−10.59108	F3V	−4.531 ± 0.479	−0.393 ± 0.471	6.669 ± 0.309	51
HIP21484	69.20860	−8.46049	B9V	−4.241 ± 0.032	−1.386 ± 0.025	6.540 ± 0.449	51
HIP16609	53.44380	8.29048	A5	26.983 ± 0.071	−23.388 ± 0.043	6.916 ± 0.264	52
TYC72-816-1	58.44870	5.70640	⋯	28.956 ± 0.742	−25.953 ± 0.467	7.503 ± 0.263	52
HIP17512	56.24565	8.31947	G5	26.671 ± 0.097	−24.288 ± 0.064	7.111 ± 0.440	52
TYC658-828-1	56.46727	8.54080	⋯	28.188 ± 0.826	−25.445 ± 0.488	7.533 ± 0.279	52
HIP17907	57.44383	9.40739	B9	25.379 ± 0.037	−24.417 ± 0.018	7.162 ± 0.509	52
TYC8180-844-1	145.55105	−51.05258	⋯	−19.043 ± 1.318	8.059 ± 0.775	8.162 ± 0.302	53
HIP48338	147.79501	−53.18296	F0/2IV	−19.648 ± 0.059	6.854 ± 0.057	7.817 ± 0.258	53
HIP46740	142.89615	−51.25188	A4/5IV/V	−21.168 ± 0.047	9.718 ± 0.051	8.252 ± 0.242	53
TYC8175-288-1	140.82228	−50.22978	⋯	−19.665 ± 1.131	10.253 ± 1.107	8.116 ± 0.380	53
TYC8584-2682-1	143.10856	−52.62763	⋯	−17.960 ± 1.958	8.918 ± 0.916	8.057 ± 0.347	53
TYC8534-396-1	94.22929	−52.87385	⋯	1.378 ± 0.731	8.411 ± 0.659	8.348 ± 0.232	56
TYC8542-1617-1	96.52613	−56.52116	G0	1.148 ± 0.820	12.801 ± 0.726	8.437 ± 0.269	56
HIP30685	96.72389	−53.58192	F0V	1.288 ± 0.075	11.312 ± 0.083	8.927 ± 0.227	56
TYC8534-211-1	95.47952	−52.73230	⋯	1.949 ± 0.922	9.413 ± 0.690	8.532 ± 0.244	56
TYC8115-252-1	96.89736	−50.77373	⋯	2.073 ± 1.563	8.170 ± 0.624	8.196 ± 0.280	56
HIP34706	107.82022	−70.11906	K0III	−20.228 ± 0.077	90.907 ± 0.066	5.774 ± 0.213	58
TYC9183-1267-1	110.73158	−69.43246	⋯	−23.350 ± 0.766	93.447 ± 0.706	5.836 ± 0.237	58
TYC8922-1022-1	113.48855	−66.31245	⋯	−25.490 ± 0.840	82.590 ± 0.797	5.844 ± 0.316	58
TYC8919-2129-1	117.55586	−65.35849	⋯	−36.701 ± 0.797	87.584 ± 0.624	5.862 ± 0.318	58
TYC8918-990-1	113.69697	−63.95839	⋯	−26.029 ± 1.078	81.378 ± 0.866	5.914 ± 0.378	58
HIP105282	319.86989	49.51030	B6V	14.414 ± 0.025	2.174 ± 0.024	6.276 ± 0.513	59
HIP103196	313.60852	48.92983	AM	13.083 ± 0.032	2.685 ± 0.030	6.263 ± 0.297	59
TYC3579-1214-1	313.08423	48.72394	⋯	12.447 ± 1.589	3.931 ± 0.859	6.251 ± 0.274	59
HIP103658	315.02763	48.67945	B9P	13.870 ± 0.031	3.278 ± 0.038	6.216 ± 0.302	59
TYC3592-755-1	315.13891	48.71559	F2	14.353 ± 0.890	2.638 ± 0.817	6.207 ± 0.266	59
TYC81-1439-1	67.13638	6.09780	A3	19.980 ± 0.663	−21.486 ± 0.487	6.215 ± 0.553	60
TYC81-986-1	65.60088	6.52921	A3	19.850 ± 0.643	−21.099 ± 0.542	6.263 ± 0.320	60
TYC80-202-1	63.96299	7.11771	⋯	23.279 ± 0.975	−25.185 ± 0.566	6.134 ± 0.268	60
TYC668-737-1	65.35161	8.89843	⋯	21.998 ± 1.326	−24.095 ± 0.707	6.166 ± 0.378	60
HIP20425	65.63759	5.69412	F5	20.631 ± 0.107	−21.217 ± 0.081	6.377 ± 0.265	60
HIP35588	110.16249	−52.19871	F3/5V	−9.239 ± 0.030	0.645 ± 0.030	6.734 ± 0.391	61
TYC8131-363-1	109.54213	−52.03277	A1V	−9.722 ± 0.514	1.429 ± 0.476	6.234 ± 0.254	61
TYC8131-1097-1	109.21415	−51.59885	F2V	−8.141 ± 0.863	0.824 ± 0.610	6.326 ± 0.260	61
TYC8127-223-1	109.63125	−50.21998	⋯	−9.479 ± 0.876	1.219 ± 0.535	6.642 ± 0.220	61

Table 9
(Continued)

Name	R.A.	Decl.	SpT	μ_α mas $^{-1}$	μ_δ mas $^{-1}$	π mas	Group
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TYC8128-923-1	111.16376	−49.76533	F0IV/V	−9.642 ± 1.025	0.925 ± 0.675	6.469 ± 0.251	61

Note. Collections of stars in Groups with five to nine connected components from the Oh17 sample that appear to be newly discovered.

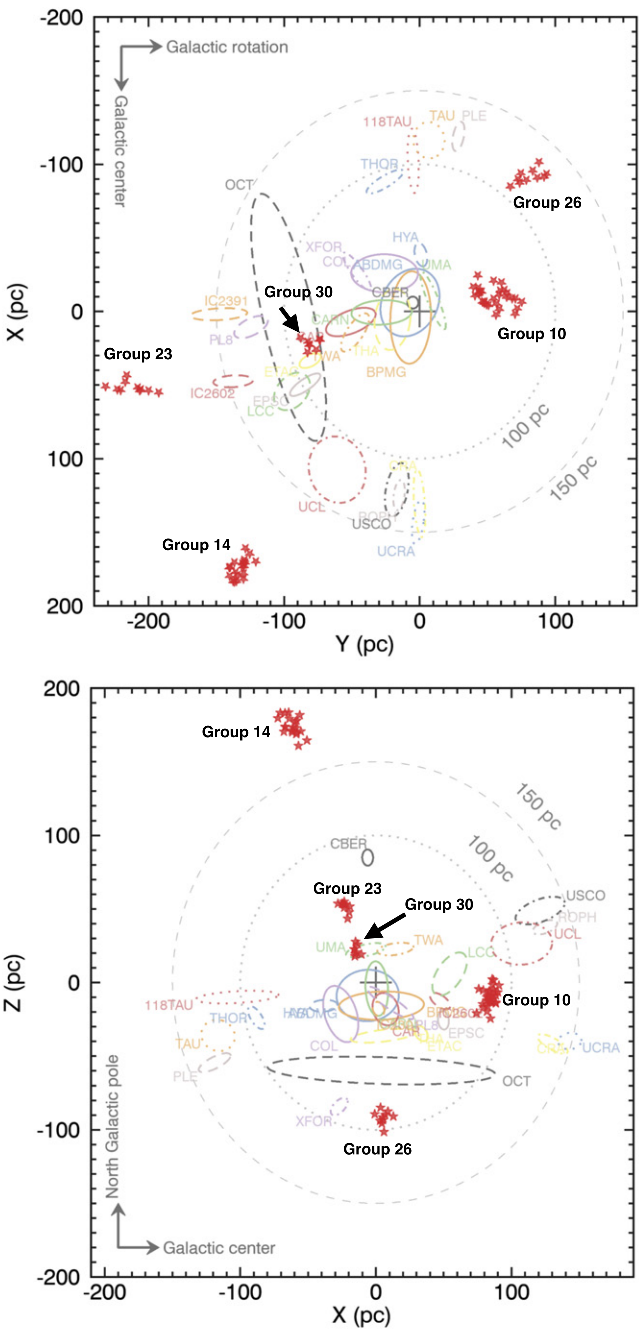

Figure 5. X vs. Y and X vs. Z positions of BANYAN Σ tested groups as well as six (five with >10 members and one with eight members) new associations discussed in this work.

4.3. Non-BANYAN but Known Groups Identified

As stated above, the Oh17 sample consists of 27 groups that have ⩾10 connected components, which we choose as a cutoff number for what we investigated as a potentially new large association. We found that 15 of those Oh17 groups contained BANYAN predicted members of nine different associations (as stated above some BANYAN groups were split among more than one Oh17 group). The remaining 12 Oh17 groups with >10 members were split between (1) known associations that were simply not tested by BANYAN and (2) potential new groups. For the former, we conducted a literature search including a cross-match with the *Gaia* Open Cluster catalog (Gaia Collaboration et al. 2017) and found that Oh17 Group 1 is α Persei, Oh17 group 6 is Praesepe, Oh17 group 9 is IC2391, Oh17 group 17 is Blanco 1, Oh17 group 21 is NGC2451A, Oh17 group 20 is Platais 3, and Oh17 group 16 is RSG 2. Table 6 lists the membership (BANYAN or not) that we found through a literature search for any source in the Oh17 sample.

4.4. New Moving Groups Identified in Oh17

Of the 27 groups that have ⩾10 connected components, five Oh17 groups appear to be newly identified. Those were Oh17 groups 10, 14, 23, and 26 (containing 29, 20, 10, and 10 connected components respectively). The stellar members and associated kinematics for each new group are listed in Table 8. Group 10 is perhaps the most exciting both because it has the largest number of members (29) and it falls within 100 pc (full range is 90–115 pc). We note that there is a reference to three of the stars (HIP 67005, HIP67231, and HIP66198) belonging to an unnamed open cluster by Latyshev (1977)—along with four other stars that were not recovered by Oh et al. (2017). However, we found no other information aside from their coordinates in a literature search.

For the remaining three groups, a quick search of the literature did not yield any indication that they were previously identified as comoving associations. Group 26 with 10 members is just a bit farther than Group 10 with a range of 105–135 pc. See Table 8 for the range of distances for all new groups as well as proper motion, radial velocity, and spectral types for their members.

For the 35 Oh17 groups with five to nine members, we find that 19 do not show any likelihood of membership in BANYAN tested groups, the *Gaia* Open Cluster catalog, or a very cursory literature search. While we do not give these the same attention as the five new groups with ⩾10 connected components, we break out their individual components in Table 9.

We note that Oh17 Group 30 is particularly exciting as it is within 100 pc (range 77–90 pc; see Figure 5). As such, we provide a G-J color–magnitude diagram for this eight component group and note that there is one fairly strong X-ray active F5 star (see Figure 6) indicating that it is Pleiades age or older. This group will be the subject of a future study.

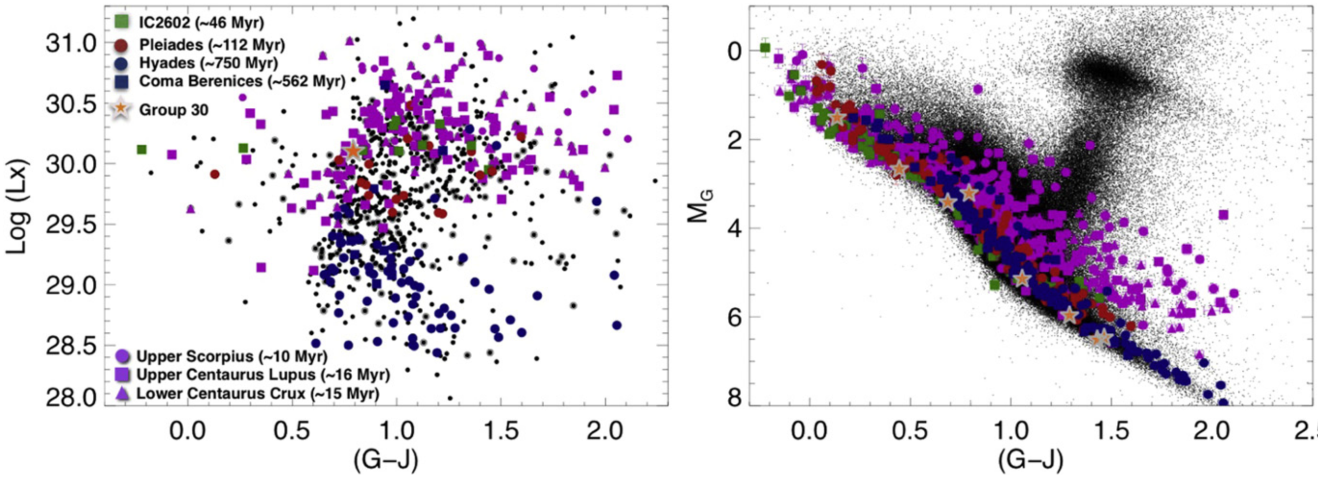

Figure 6. See the caption of Figure 7. Group 30 from Oh17 is highlighted. No FUV or NUV detections were found for objects; therefore, those panels are blank in the figure.

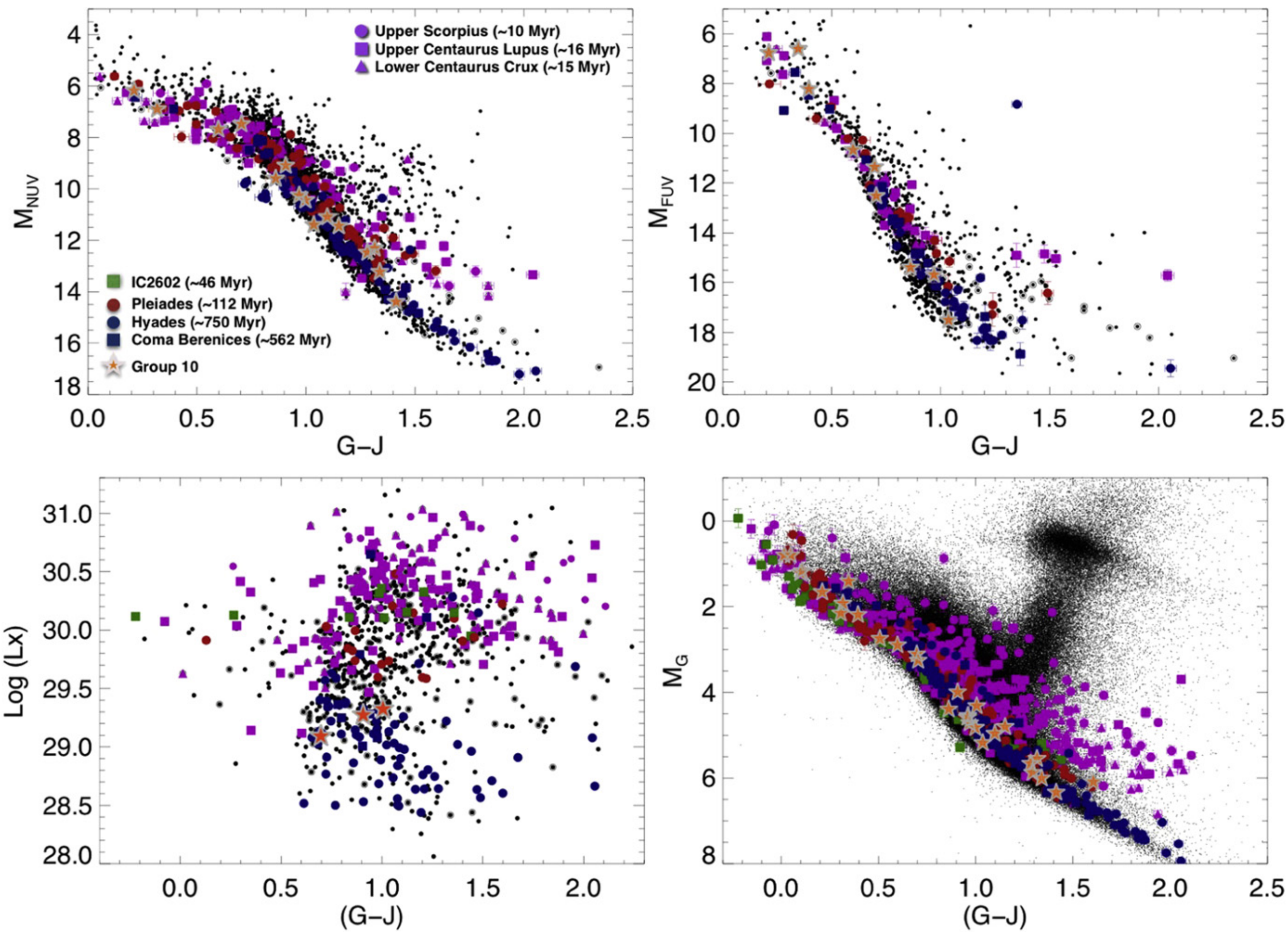

Figure 7. Suite of color–magnitude diagrams and an X-ray luminosity diagram highlighting the newly uncovered Group 10 from the Oh17 sample (orange five-point stars). At the top left, we show the $(G - J)$ vs. $M_{\rm NUV}$ CMD for the full Oh17 sample (black) with select BANYAN Σ selected groups highlighted to show different age bins. Circled in black are Oh17 sources in known associations not otherwise color coded. At the top right, we show the $(G - J)$ vs. $M_{\rm FUV}$ CMD. Bottom left is the $(G - J)$ vs. $\log(L_X)$. Bottom right is the $(G - J)$ vs. M_G CMD with all of TGAS stars with parallax signal-to-noise >10 shown as black points.

5. Age Estimates of the Five New Moving Groups from X-Ray and UV Activity

We investigated the five new groups for age-indicative information among members. First, we plotted each in XYZ space to examine whether they overlapped in position with any of the BANYAN Σ known groups. Figure 5 shows the results. While each group occupies a tight portion in XY or XZ space, most are too distant for comparison and we find no obvious connection to known associations.

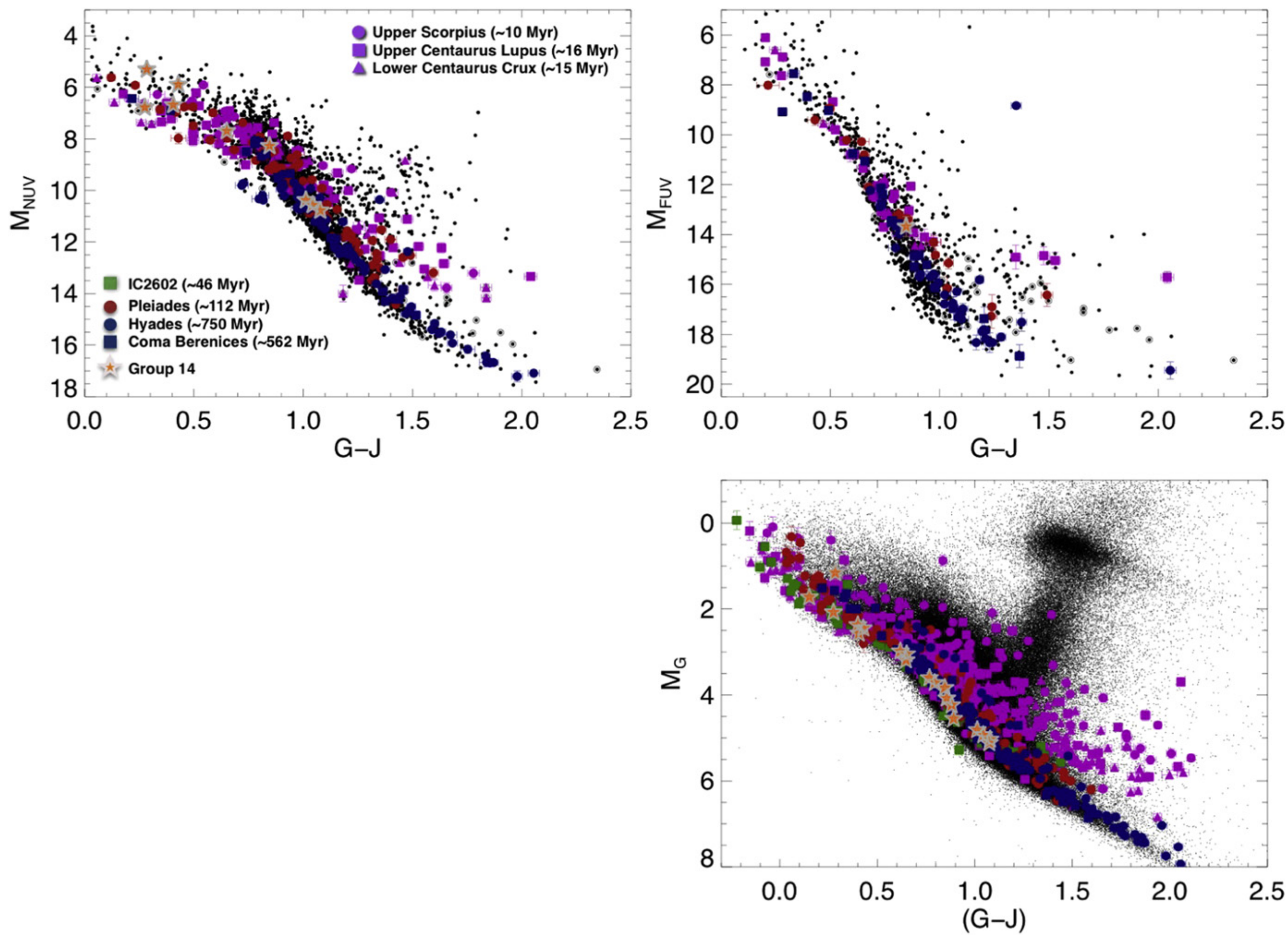

Figure 8. See the caption of Figure 7. Group 14 from Oh17 is highlighted. No *ROSAT* detections were found for objects; therefore, this panel is blank in the figure.

There is a significant portion of stars in each group that have spectral information. In Group 10, the closest of the new groups, there are AFG and K stars. Group 14 only has A stars with literature spectral types, while groups 23 and 26 have FG and A stars.

To ascertain whether these new groups follow a logical temperature sequence, and how that sequence is related to known groups with ages, we examined a series of color–magnitude diagrams. As stated in Section 3, we cross-matched all unique stars in the Oh17 sample with 2MASS, WISE, *GALEX*, and *ROSAT*. We used $(G - J)$ as our color proxy for spectral type/effective temperature as this appeared to have a clean relationship after examining an array of photometric combinations. The bottom right panels of Figures 7–10 show $(G - J)$ versus M_G for all of TGAS using a signal-to-noise cut off of 10. Overplotted are the individual stars in each of the four uknown groups (respective to their own figure) as well as BANYAN groups that were identified in Oh17 color coded to reflect different ages. We chose to group objects into age bins of ∼15 Myr with Upper Scorpius, Upper Centaurus Lupus, and Lower Centaurus Crux; ∼50 Myr with IC2602; ∼100 Myr with the Pleiades; and ∼500–800 Myr with the Hyades and Coma Berenices. Moving from blue to red $(G - J)$ color on the sequence, we see that the younger groups shift redder and brighter than would be expected from field stars. Each new group forms a fairly tight sequence across the range of $(G - J)$ colors. No group looks as young as the ∼15 Myr sequences. While the groups show some scatter, they are all consistent with Pleiades age (∼100 Myr) or older associations.

Using X-ray and UV magnitudes, we examined how the different groups (known and new) as well as the full sample measured on age-activity relations (e.g., Preibisch & Feigelson 2005; Shkolnik et al. 2011; Rodriguez et al. 2013; Núñez & Agüeros 2016). We looked at the color–magnitude diagrams of $(G - J)$ versus $M_{\rm NUV}$ and $M_{\rm FUV}$ as well as $(G - J)$ versus X-ray luminosity. The top panels of Figures 7–10 show NUV and FUV color–magnitude diagrams for each group separately while the bottom left panel of each figure shows the X-ray comparison. Each group had several stars with NUV detections. Groups 23 and 26 had no FUV detections and Group 14 had one. In X-ray, Groups 14 and 23 had no detections in *ROSAT*. Similar to the $(G - J)$ versus M_G color–magnitude diagram comparisons, we find that the new groups follow logical sequences on the ultraviolet diagrams. The FUV and NUV magnitude sequences are consistent with ages that are older than the Pleiades for each group. The X-ray activity indicates that Group 10 is similar to Hyades members at ages of ∼750 Myr. While Group 26 has stars that are more active and could be considered much younger with this diagnostic parameter.

6. Age, Mass, and Metallicity from Isochronal Fitting

We also turned to isochrone fitting to investigate the parameters of each new group. Using the methodology of

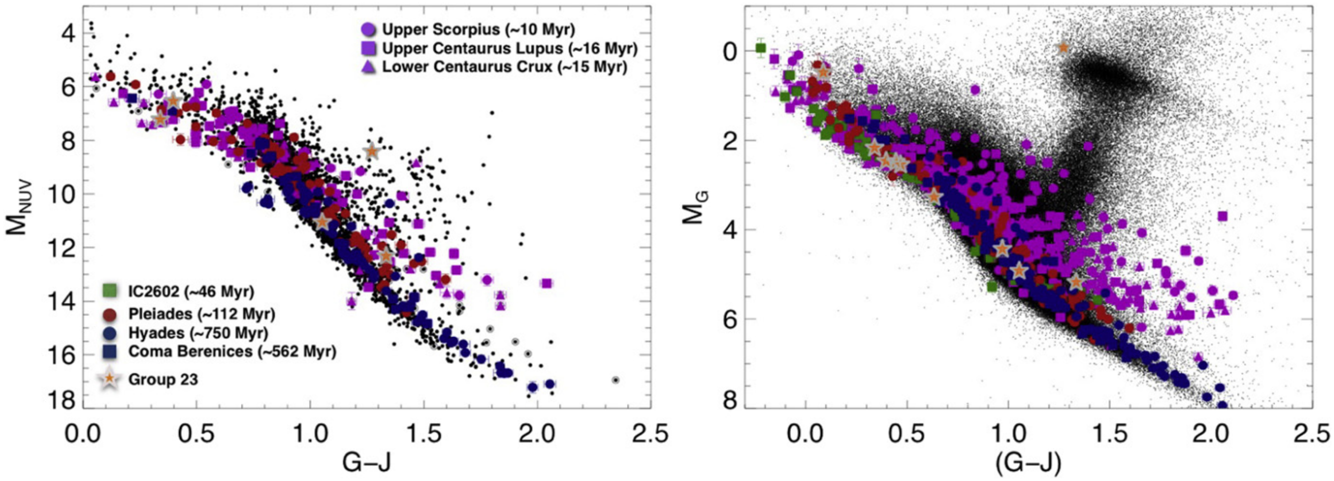

Figure 9. See the caption of Figure 7. Group 23 from Oh17 is highlighted. No *ROSAT* or FUV detections were found for objects; therefore, those panels are blank in the figure.

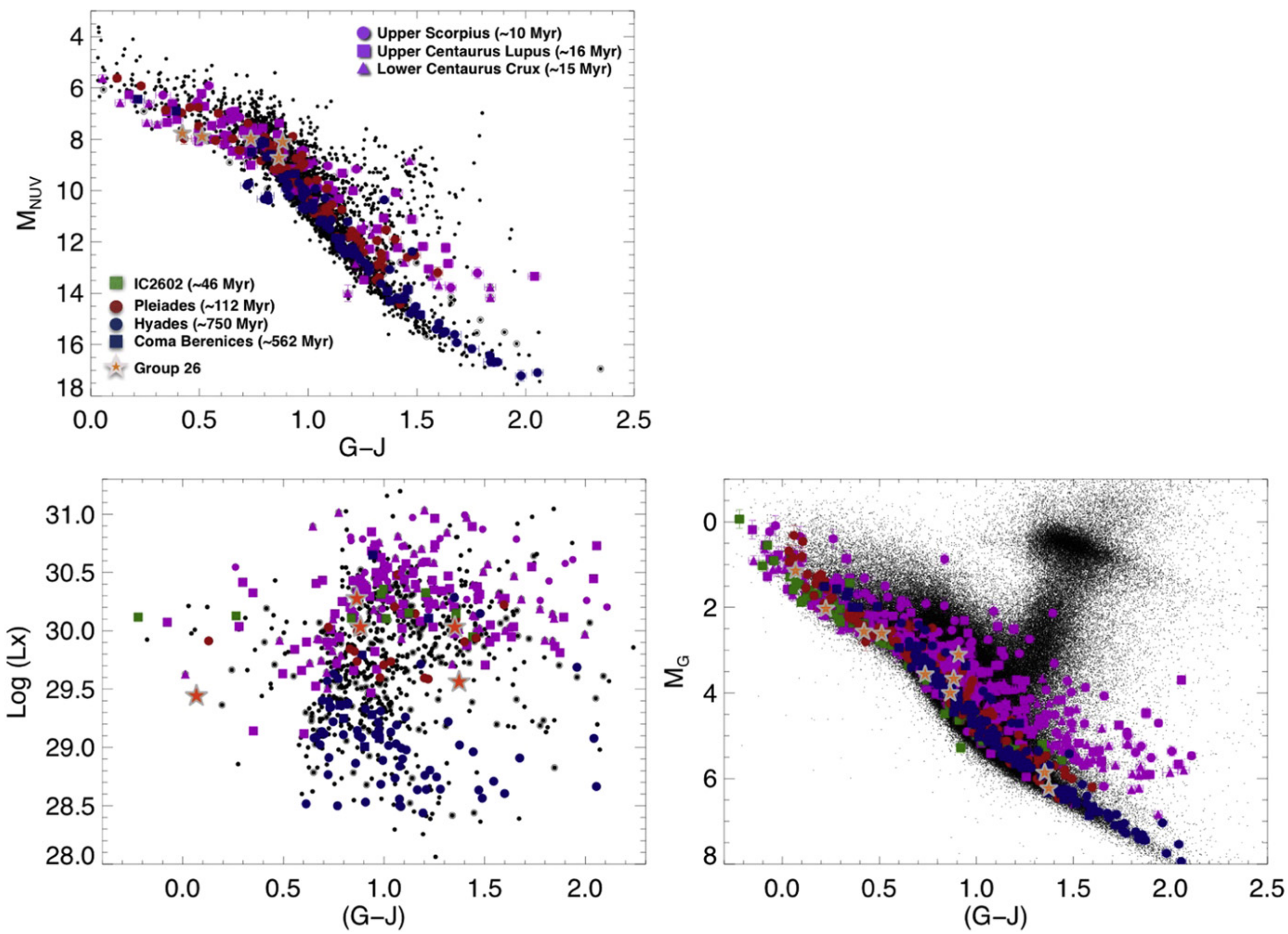

Figure 10. See the caption of Figure 7. Group 26 from Oh17 is highlighted. No FUV detections were found for objects; therefore, this panel is blank in the figure.

Bochanski et al. (2018), where the Oh17 sample was supplemented with 2MASS and WISE photometry and then tested with posterior probabilities calculated using the trilinear interpolation schemes within isochrones and assumed priors described in Morton (2015), we look at the Mesa Isochrones and Stellar Track library (MIST; Paxton et al. 2011, 2013, 2015; Choi et al. 2016; Dotter 2016) predictions for each star. We investigate both the age as well as the mass and [Fe/H] parameters. Figures 11–14 show the results for each group. For context, we overplotted one group in each of our age bins with MIST isochrone parameters from Bochanski et al. (2018): Upper Scorpius (∼10 Myr; purple), Pleiades (∼112 Myr; red),

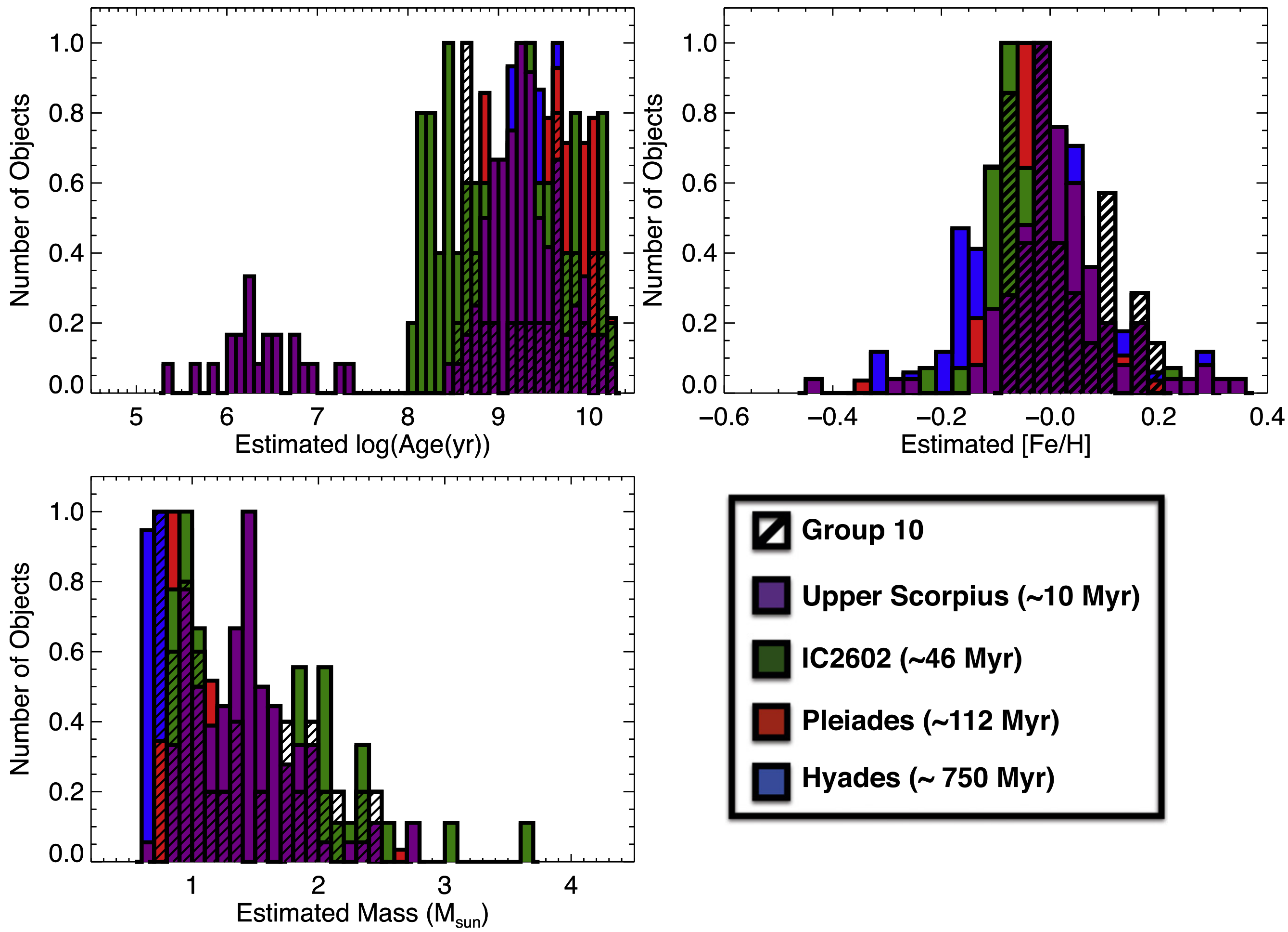

Figure 11. Output of log (age), [Fe/H], and mass parameters from MIST isochrone fitting as described in Bochanski et al. (2018). For context, we show both the group of interest (Group 10) as well as known associations at specific age bins: Upper Scorpius (∼10 Myr; purple), IC2602 (∼46 Myr; green), Pleiades (∼112 Myr; red), and Hyades (∼750 Myr; Blue)

IC2602 (∼50 Myr; green), and the Hyades (∼750 Myr; blue). The histogram plots were normalized to 1 for ease of comparison and they were binned by 0.1 in mass and age and 0.03 in [Fe/H]. As stated in Bochanski et al. (2018), the age predictions from MIST isochrone fitting are scattered and can be significantly different than observable indications like Li depletion, gyrochronology, or UV/X-ray activity levels. As such, we note the isochrone age predictions with skepticism and are more interested in the mass and [Fe/H] distribution of the groups.

6.1. Group 10

Group 10 shows a slight bifurcation in age predictions from isochrones with half of the stars showing an indication of ages younger than 1 Gyr and the other half falling older. The metallicity distribution tends to be near solar if not slightly metal-rich compared to the known group predictions. The stars identified in Group 10, the closest of the new groups examined, tend toward solar mass with a large number of higher mass objects. There are several A stars in Group 10 spectroscopically identified, so this is consistent with literature work on the members.

6.2. Groups 14 and 26

Groups 14 and 26 show isochrone age predictions for the stellar members that fall within the known associations plotted. The metallicity predictions for stars in each group all fall slightly subsolar but are within the predictions of known groups. The vast majority of stars identified in Groups 14 and 26 fall between 1 and 2 solar masses, consistent with what we see on the color–magnitude diagram sequences.

6.3. Group 23

Group 23 has 10 members, one of which falls clearly in the giant star area of the $(G-J)$ versus M_G color–magnitude diagram. That object, HD86703, also skews the age, mass, and metallicity plots by showing up as significantly younger, slightly metal-rich, and high mass. Otherwise, Group 23 is similar to Groups 14, 16, and 26 in its parameters. Indeed HD86703 is the bright outlier on the NUV color–magnitude diagram of Figure 9 and is classified as a G5/G6 giant star in the literature.

7. Conclusions

The Oh17 comoving catalog is rich with discoveries for the local solar neighborhood and the nearby galactic substructure.

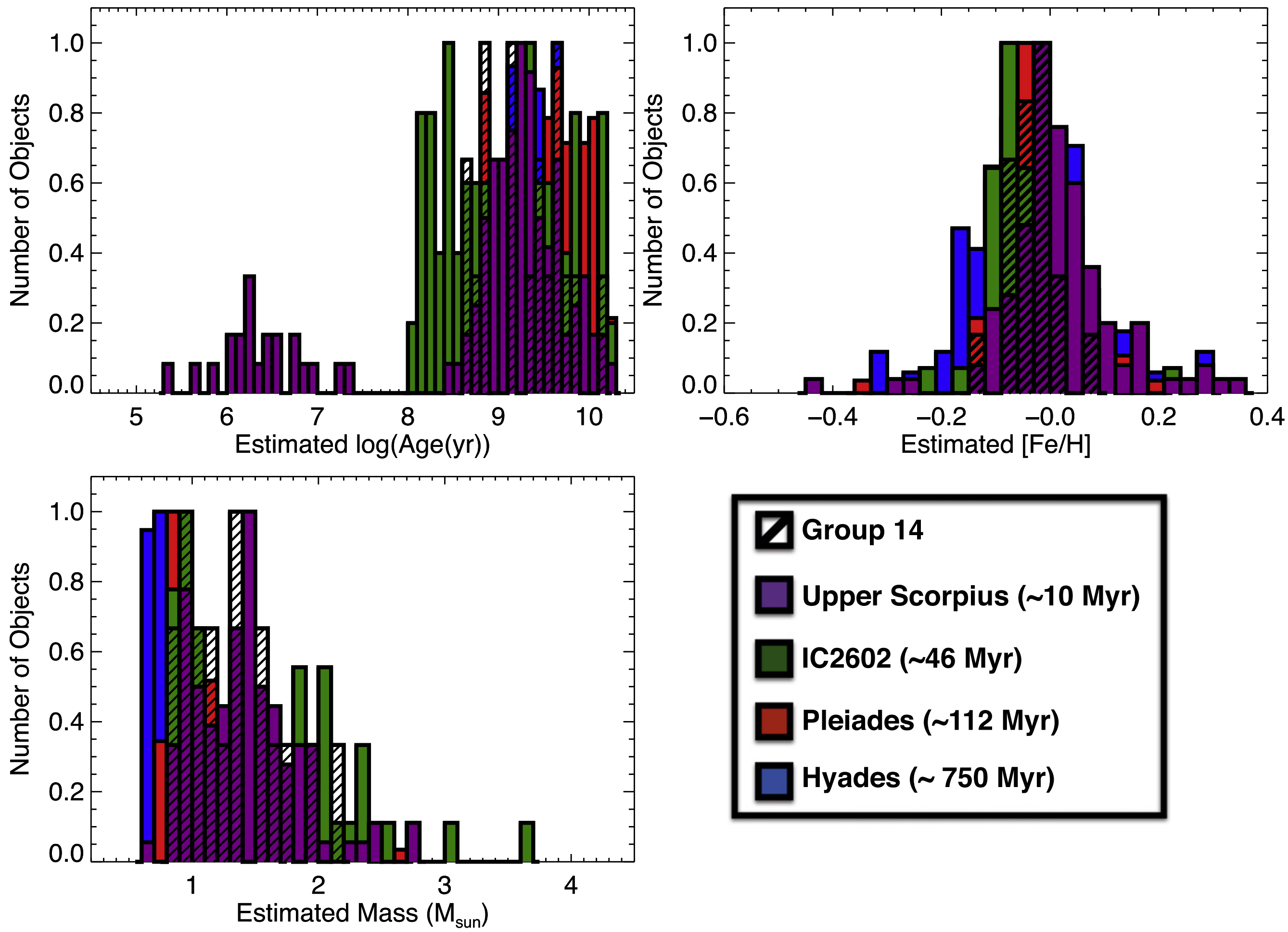

Figure 12. See the caption of Figure 11. Group 14 from Oh17 is highlighted.

There were 10,606 individual stars in the Oh17 catalog split into 4555 groups. Those were further broken down into 27 groups with 10 or more connected components, 35 groups with 5–9, 39 groups with 4, 218 that have three, and the remaining that have 2.

The original Oh17 paper produced a rich and very useful catalog; however, it lacked a detailed literature search as to whether the groups were new, known, or parts of a whole. Given that future *Gaia* data releases will certainly uncover a wealth of previously unrecognized associations in the Galaxy, we looked to reorganize the sample of 4555 groups into known or unknown collections of stars. The BANYAN Σ tool is one method for quickly parsing through the collection of pairs and hierarchical associations. Using BANYAN Σ, we find that 1015 individual stars in the Oh17 catalog have an 80% or larger probability of membership in 1 of the 27 groups analyzed. Using those objects as a seed for interpretation of the overall Oh17 catalog, we find that 24 of the 27 groups were uncovered in part (none in their entirety), and there are 400 new candidate members with *Gaia* astrometry across 20 different groups. In fact, a significant portion were uncovered as bonafide members in the literature and the Oh17 catalog found a comoving companion or multiple connected companions with >80% probability in a group.

We uncovered that a significant number of the large (>10 connected component) groups in the Oh17 sample were broken up parts of big, known associations like Upper Centaurus Lupus, Upper Centaurus Crux, or Upper Scorpius. We found no correlation with the individual Oh17 group and position on color–magnitude diagrams; therefore, we do not identify traces of substructure in those known associations; however, recent work suggests that further investigation is warranted (see Röser et al. (2018) and the discovery that Oh17 Group 11 was a compact new moving group around V1062 Sco).

We investigated the Oh17 groups with >10 connected components in detail and found that four of those hierarchical associations are newly discovered comoving collections of stars in the Milky Way. Among those were Oh17 Groups 10, 14, 23, and 26 containing 29, 20, 10, and 10 connected components each. Group 10 was the closest with a range of 105–135 pc making it a new candidate for searches of a coevolving association with directly imaged exoplanets and brown dwarfs. Each group appears to be older than the Pleiades but with indications that they are younger than ∼1 Gyr. Using the kinematics of these objects in updates of strong kinematic analysis tools like BANYAN Σ, one can uncover more members. Moreover, while we did not perform a detailed search, we found that 19 of the 35 Oh17 groups

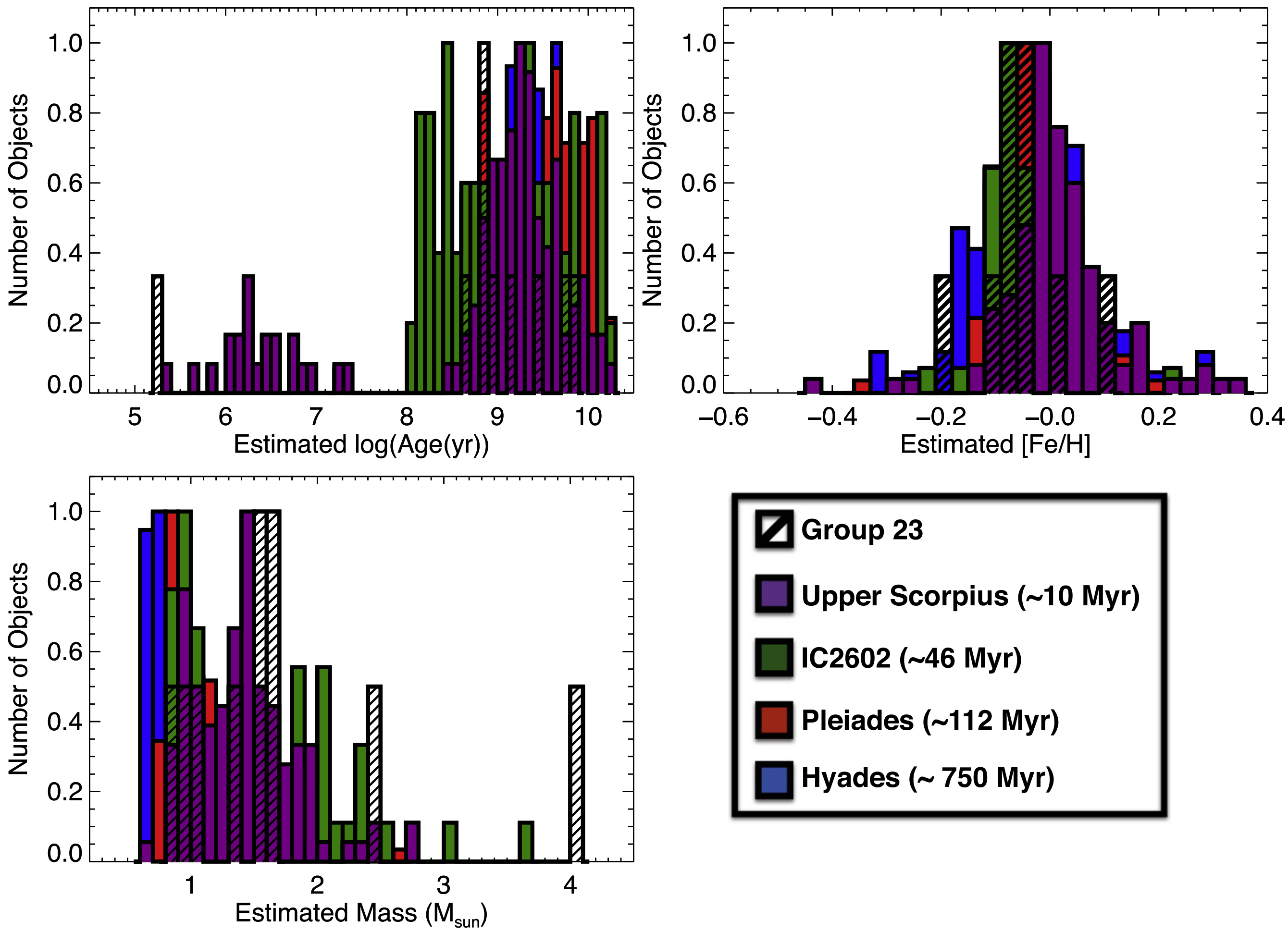

Figure 13. See the caption of Figure 11. Group 23 from Oh17 is highlighted.

with five to nine members also appeared to be new comoving associations in the Galaxy and warrant follow-up. Oh17 group 30 was particulary exciting given that it would be well within 100 pc (range of 77–90 pc), has at least one X-ray active F5 star, and is in a compact area of young stars near the Sun. Given that the *Gaia* DR2 release will occur in 2018 April, these new groups are likely just the tip of a large iceberg of discovery when it comes to the substructure of the Milky Way.

We thank Dustin Lang for providing the *Gaia*-Tycho-2MASS cross-match data, and Seomyong Oh for useful conversations about the original catalog. We also thank amateur astronomer Bruno Alessi for pointing out a recently discovered cluster. This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory; the SIMBAD database and VizieR catalog access tool, operated at the Centre de Donnees astronomiques de Strasbourg, France (Ochsenbein et al. 2000); data products from the Two Micron All Sky Survey (2MASS; Skrutskie et al. 2006), which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center (IPAC)/California Institute of Technology (Caltech), funded by the National Aeronautics and Space Administration (NASA) and the National Science Foundation; data products from the Wide-field Infrared Survey Explorer (WISE; and Wright et al. 2010), which is a joint project of the University of California, Los Angeles, and the Jet Propulsion Laboratory (JPL)/Caltech, funded by NASA. This project was developed in part at the 2017 Heidelberg *Gaia* Sprint, hosted by the Max-Planck-Institut fur Astronomie, Heidelberg. This work has made use of data from the European Space Agency (ESA) mission *Gaia*, processed by the *Gaia* Data Processing and Analysis Consortium. Funding for the DPAC has been provided by national institutions, in particular, the institutions participating in the *Gaia* Multilateral Agreement. With deepest appreciation, we acknowledge Kathryn W. Davis for her generous founding support of the Master of Arts in Science Teaching (MAT) Program. Leadership support for the MAT program is provided by The Shelby Cullom Davis Charitable Fund. The MAT program is supported in part by the National Science Foundation under Grant Number DUE-1340006 and the U.S. Department of Education under Grant Number U336S140026.

Software: BANYAN (Gagné et al. 2018a), isochrones (Morton 2015), TOPCAT (Taylor 2005).

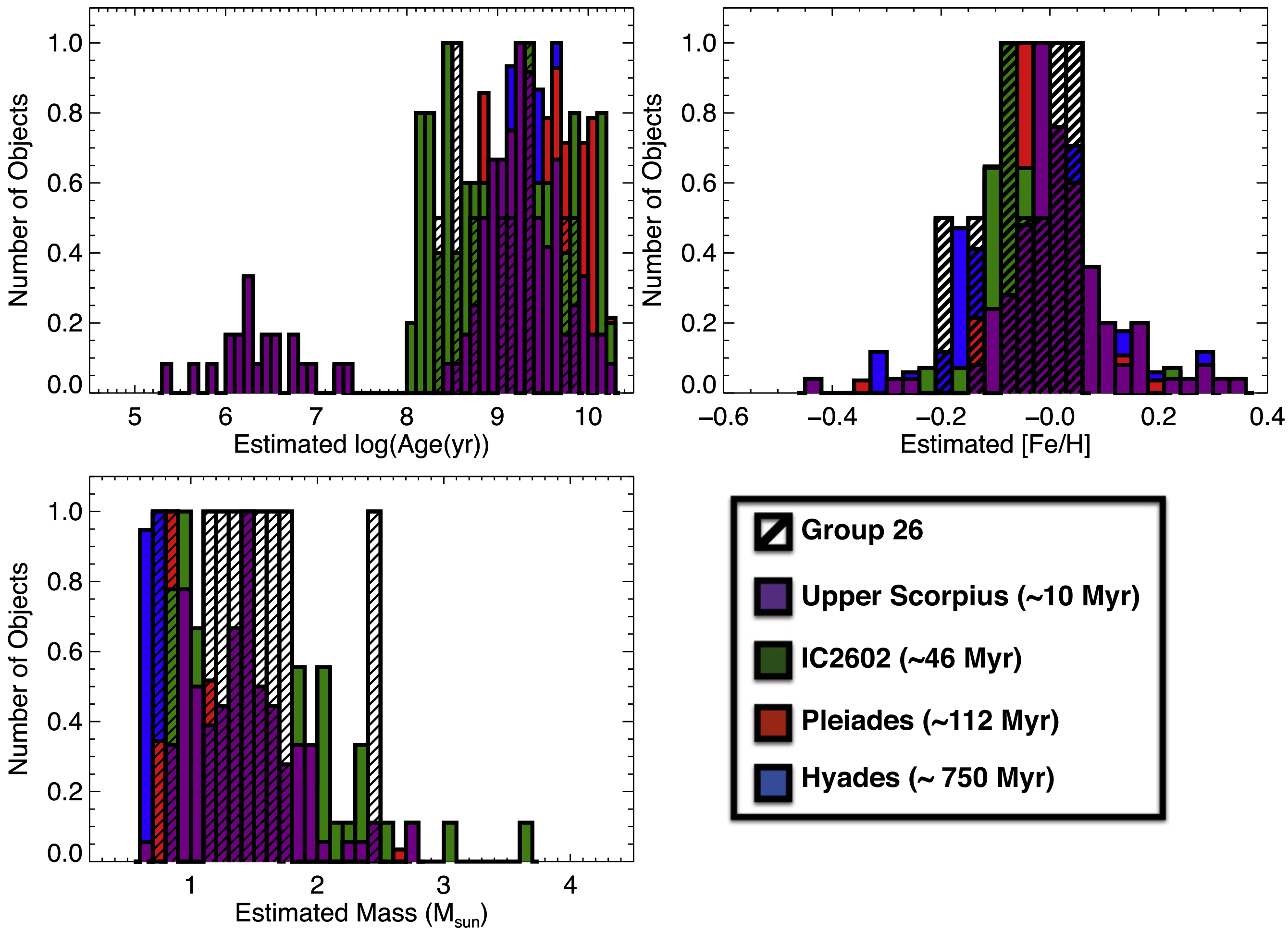

Figure 14. See the caption of Figure 11. Group 26 from Oh17 is highlighted.

ORCID iDs

Jacqueline K Faherty https://orcid.org/0000-0001-6251-0573
John J. Bochanski https://orcid.org/0000-0001-7096-425X

References

Aitken, R. G. 1895, PASP, 7, 305
Andrews, J. J., Chanamé, J., & Agüeros, M. A. 2017, MNRAS, 472, 675
Andrews, J. J., Chanamé, J., & Agüeros, M. A. 2018, MNRAS, 473, 5393
Barrado y Navascués, D., Stauffer, J. R., & Jayawardhana, R. 2004, ApJ, 614, 386
Bell, C. P. M., Mamajek, E. E., & Naylor, T. 2015, MNRAS, 454, 593
Bochanski, J. J., Faherty, J. K., Gagné, J., et al. 2018, AJ, 155, 149
Brandt, T. D., & Huang, C. X. 2015a, ApJ, 807, 58
Brandt, T. D., & Huang, C. X. 2015b, ApJ, 807, 24
Chanamé, J., & Ramírez, I. 2012, ApJ, 746, 102
Choi, J., Dotter, A., Conroy, C., et al. 2016, ApJ, 823, 102
Daemgen, S., Bonavita, M., Jayawardhana, R., Lafrenière, D., & Janson, M. 2015, ApJ, 799, 155
Dahm, S. E. 2015, ApJ, 813, 108
Dhital, S., West, A. A., Stassun, K. G., & Bochanski, J. J. 2010, AJ, 139, 2566
Dhital, S., West, A. A., Stassun, K. G., Schluns, K. J., & Massey, A. P. 2015, AJ, 150, 57
Dobbie, P. D., Lodieu, N., & Sharp, R. G. 2010, MNRAS, 409, 1002
Dotter, A. 2016, ApJS, 222, 8
Eggen, O. J. 1965, in Moving Groups of Stars, ed. A. Blaauw & M. Schmidt (Chicago, IL: Univ. Chicago Press), 111
Faherty, J. K., Burgasser, A. J., Bochanski, J. J., et al. 2011, AJ, 141, 71
Faherty, J. K., Burgasser, A. J., West, A. A., et al. 2010, AJ, 139, 176
Faherty, J. K., Riedel, A. R., Cruz, K. L., et al. 2016, ApJS, 225, 10
Gagné, J., & Faherty, J. K. 2018, MNRAS, submitted (arXiv:1805.11715)
Gagné, J., Faherty, J. K., Cruz, K. L., et al. 2015, ApJS, 219, 33
Gagné, J., Faherty, J. K., Mamajek, E. E., et al. 2017, ApJS, 228, 18
Gagné, J., Mamajek, E. E., Malo, L., et al. 2018a, ApJ, 856, 23
Gagné, J., Roy-Loubier, O., Faherty, J. K., Doyon, R., & Malo, L. 2018b, ApJ, 860, 43
Gaia Collaboration, van Leeuwen, F., Vallenari, A., et al. 2017, A&A, 601, 19
Gennaro, M., Prada Moroni, P. G., & Tognelli, E. 2012, MNRAS, 420, 986
Høg, E., Fabricius, C., Makarov, V. V., et al. 2000, A&A, 355, L27
Jones, J., White, R. J., Boyajian, T., et al. 2015, ApJ, 813, 58
Kapteyn, J. C. 1905, British Assoc. Adv. Sci. Rep., 257
Kenyon, S. J., & Hartmann, L. 1995, ApJS, 101, 117
Kirkpatrick, J. D., Dahn, C. C., Monet, D. G., et al. 2001, AJ, 121, 3235
Kushniruk, I., Schirmer, T., & Bensby, T. 2017, A&A, 608, A73
Latyshev, I. N. 1977, ATsir, 969, 7
Lépine, S. 2005, AJ, 130, 1247
Lépine, S., & Bongiorno, B. 2007, AJ, 133, 889
Lépine, S., & Shara, M. M. 2005, AJ, 129, 1483
Lindegren, L., Lammers, U., Bastian, U., et al. 2016, A&A, 595, A4
Mamajek, E. 2016, A New Candidate Young Stellar Group at d = 121 pc Associated with 118 Tauri, Figshare
Martin, D. C., Fanson, J., Schiminovich, D., et al. 2005, ApJL, 619, L1
Mason, B. D., Wycoff, G. L., Hartkopf, W. I., Douglass, G. G., & Worley, C. E. 2018, yCat, 102026
Morton, T. D. 2015, Isochrones: Stellar Model Grid Package, Astrophysics Source Code Library, ascl:1503.010
Murphy, S. J., & Lawson, W. A. 2015, MNRAS, 447, 1267
Murphy, S. J., Lawson, W. A., & Bessell, M. S. 2013, MNRAS, 435, 1325
Núñez, A., & Agüeros, M. A. 2016, ApJ, 830, 44
Ochsenbein, F., Bauer, P., & Marcout, J. 2000, A&AS, 143, 23
Oelkers, R. J., Stassun, K. G., & Dhital, S. 2017, AJ, 153, 259
Oh, S., Price-Whelan, A. M., Brewer, J. M., et al. 2018, ApJ, 854, 138

Oh, S., Price-Whelan, A. M., Hogg, D. W., Morton, T. D., & Spergel, D. N. 2017, AJ, 153, 257
Paxton, B., Bildsten, L., Dotter, A., et al. 2011, ApJS, 192, 3
Paxton, B., Cantiello, M., Arras, P., et al. 2013, ApJS, 208, 4
Paxton, B., Marchant, P., Schwab, J., et al. 2015, ApJS, 220, 15
Pecaut, M. J., & Mamajek, E. E. 2016, MNRAS, 461, 794
Perryman, M. A. C., Lindegren, L., Kovalevsky, J., et al. 1997, A&A, 323, L49
Platais, I., Kozhurina-Platais, V., & van Leeuwen, F. 1998, AJ, 116, 2423
Pöhnl, H., & Paunzen, E. 2010, A&A, 514, A81
Preibisch, T., & Feigelson, E. D. 2005, ApJS, 160, 390
Price-Whelan, A. M., Oh, S., & Spergel, D. N. 2017, arXiv:1709.03532
Rodriguez, D. R., Zuckerman, B., Kastner, J. H., et al. 2013, ApJ, 774, 101
Röser, S., Schilbach, E., & Goldman, B. 2016, A&A, 595, A22
Röser, S., Schilbach, E., Goldman, B., et al. 2018, A&A, 614, A81
Shaya, E. J., & Olling, R. P. 2011, ApJS, 192, 2
Shkolnik, E. L., Liu, M. C., Reid, I. N., Dupuy, T., & Weinberger, A. J. 2011, ApJ, 727, 6
Silaj, J., & Landstreet, J. D. 2014, A&A, 566, A132
Skiff, B. A. 2014, yCat, 2023
Skrutskie, M. F., Cutri, R. M., Stiening, R., et al. 2006, AJ, 131, 1163
Taylor, M. B. 2005, in ASP Conf. Ser. 347, Astronomical Data Analysis Software and Systems XIV, ed. P. Shopbell, M. Britton, & R. Ebert (San Francisco, CA: ASP), 29
Teske, J. K., Ghezzi, L., Cunha, K., et al. 2015, ApJL, 801, L10
Voges, W., Aschenbach, B., Boller, T., et al. 1999, A&A, 349, 389
Voges, W., Aschenbach, B., Boller, T., et al. 2000, yCat, 9029
Weinberg, M. D., Shapiro, S. L., & Wasserman, I. 1987, ApJ, 312, 367
Wilking, B. A., Gagné, M., & Allen, L. E. 2008, in Handbook of Star Forming Regions II, ed. B. Reipurth (Tucson, AZ: Univ. Arizona Press), 351
Wright, E. L., Eisenhardt, P. R. M., Mainzer, A. K., et al. 2010, AJ, 140, 1868
Zuckerman, B., Bessell, M. S., Song, I., & Kim, S. 2006, ApJL, 649, L115